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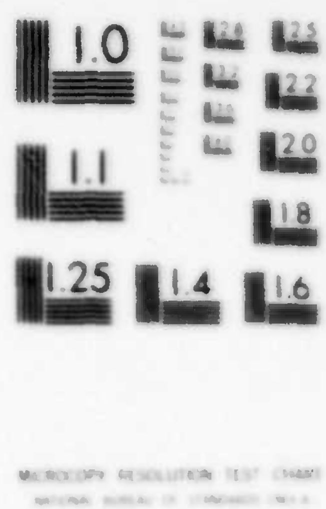

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This study was conducted to determine the biological activity and chemical characteristics of dredge material from ten sites on the Upper Mississippi River between St. Paul and Winona, Minnesota.

Sediment samples from the ten sites were characterized as being of two types: predominately sand and fine sand with substantial amounts of silt, clay and colloidal materials. Toxic activity observed in particulate phase exposures was related to the type of sediment material. Samples which

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predominantly sand were essentially nontoxic, samples which contained substantial amounts of silt, clay and colloidal material often produced a toxic effect (mortality).

The only sediment samples which were classified as heavily polluted were those from the Red Wing Commercial Harbor and the St. Paul Barge Terminal. These two samples consisted of large proportions of silt and clay and reflected a strong inverse correlation noted between particle size and concentration of the contaminants amoung the ten sample sites.

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ABSTRACT

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) are responsible for developing guidelines to regulate the disposal of dredged material. Many governmental and private interest groups in the Mississippi River basin are concerned about potential hazards associated with the possible release of contaminant substances during dredging activities and the deleterious effects that resuspended materials may have on aquatic organisms. This study was conducted to determine the biological activity and chemical characteristics of dredge material from 10 sites on the Upper Mississippi River between St. Paul and Winona, Minnesota. Funds for the study were provided by the St. Paul District of the COE.

Toxic effects were assessed in static bioassays by exposing aquatic organisms to (1) sediments under stable water conditions, and (2) suspended particulate materials that were maintained in suspension by aeration. Organisms tested involved scuds (_Gammarus pseudolimnaeus_), crayfish (_Procambarus_ sp.), mayfly nymphs (_Hexagenia_ sp.), midge larvae (_Chironomus tentans_), snails (_Physa gyrina_), fawnfoot mussels (_Truncilla donaciformis_), fingernail clams (_Sphaerium_ sp.), fathead minnows (_Pimephales promelas_), and channel catfish (_Ictalurus punctatus_).

Chemical characteristics were determined by standard analytical procedures for three types of sample preparations: (1) sediment per se, (2) suspended particulate materials, and (3) a filtered elutriate. Analyses were run to determine volatile solids, pH, COD, BOD, total phosphate, ortho phosphate, ammonia nitrogen, nitrite and nitrate nitrogen, oil and grease, chromium, copper, lead, zinc, nickel, mercury, cadmium, PCB's, DDD, DDE, DDT, endrin, dieldrin, and chlordane.

Sediment samples from the 10 sites were characterized as being of two types: (1) predominantly sand, and (2) fine sand with substantial amounts of silt, clay, and colloidal materials. Toxic activity observed in particulate phase exposures was related to the type of sediment material. Samples which contained predominantly sand were essentially nontoxic; samples which contained substantial amounts of silt, clay, and colloidal material often produced a toxic effect (mortality).

Samples from the Red Wing Commercial Harbor and St. Paul Barge Terminal were the only ones that produced mortality among aquatic organisms. As a rule, particulate phase exposures were more toxic than solid phase exposures. Samples from the eight remaining sites were essentially nontoxic in both types of exposures.

Concentrations of the various chemicals were generally highest for total sediment samples; values for suspended particulates were generally higher than those for millipore filtered elutriates. Most contaminants were not extractable in water. This was indicated by the low contaminant concentrations found in elutriate samples. There is little likelihood that many of the observed concentrations of contaminants, by themselves, would be acutely toxic to aquatic organisms. Ammonia nitrogen, cadmium, and zinc in the more heavily contaminated samples approached lethal concentrations moreso than other contaminants, but those concentrations were still sublethal.

The only sediment samples which were classified as heavily polluted, based on analyses for the various contaminants, were those from the Red Wing Commercial Harbor and the St. Paul Barge Terminal. These two samples consisted of large proportions of silt and clay and reflected a strong inverse correlation noted between particle size and concentration of the contaminants among the 10 sample sites.

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (COE) are responsible for developing guidelines to regulate the disposal of dredged material. Many federal, state, and private interests in the Mississippi River basin are concerned about potential hazards that might be associated with the possible resuspension of contaminant substances during dredging processes, and that resuspended materials may have deleterious effects on aquatic organisms. This study was undertaken to assess the biological activity and chemical characteristics of dredge materials and their potential acute effects on the river biota.

In a study supported by EPA funds, Prater and Anderson (1977) conducted bioassays on eight sediments collected from Duluth, Minnesota, and Superior, Wisconsin, harbors on Lake Superior. Sites were chosen in their study to reflect areas suspected to be heavily, moderately, or nonpolluted. They reported that none of the sediment samples produced 100% mortality among the groups of organisms exposed, and five of the sediments produced less than a 30% mortality among *Hexagenia limbata* (mayfly), *Daphnia magna* (water flea), *Pimephales promelas* (fathead minnow), and *Asellus communis* (scud). *Daphnia magna* appeared to be the most sensitive organism, and *Hexagenia limbata* was next in sensitivity. Chemical characteristics were reported for all sediment samples, but the authors could not correlate mortality of test organisms with any of the individual chemical components.

The Waterways Experiment Station at Vicksburg, Mississippi has done considerable work on dredge material including methodologies for determining impacts of dredged material, disposal of dredged material,

and contaminant releases from dredge materials (Shuba et al. 1977; Jones and Lee 1978; and Peddicord et al. 1979). Although methods for sediment studies have been standardized to some extent, modification and updating of certain procedures continue to be reported as techniques are developed.

Peddicord et al. (1979) studied sediments from the Upper Mississippi River (UMR), and reported low toxicity to all aquatic species they tested except amphipods. Bioaccumulation of PCB's and metals in tissues of invertebrates exposed to sediments occurred in only 11% of their tests. Peddicord et al. (1979) suggested that typical dredging and disposal operations on the Upper Mississippi River have little potential to cause short-term ecological effects due to increases in mortality or bioaccumulation of contaminants in the species studied.

Methodology for the study reported here was specified by the contractee and modified as appropriate to simulate and evaluate "worst case" conditions. For instance, a 5-minute settling time for suspended particulates rather than a 1-hour settling time (Peddicord et al. 1979) was adopted to evaluate the impacts of spoil deposition near the discharge point of dredged material.

The objectives of this study were to (1) determine the biological activity of sediments, whether due to toxicity of contaminants contained in the sediments or to the effects of physical impact of particulate matter on representative organisms common to the Mississippi River and (2) determine the chemical characteristics of the dredge materials. Biological activity (Part I of this study) was evaluated by exposing aquatic organisms to dredge material per se (solid phase) in suitable dilution water and to solutions containing suspended particulate matter

(suspended particulate phase). Chemical characterization (part II) involved analysis of three phases of dredge material--solid phase, suspended particulate phase, and a filtered elutriate or liquid phase. Chemical analyses were done according to standardized laboratory procedures or modifications thereof to accommodate the peculiar materials involved.

PART I

METHODS FOR BIOLOGICAL TESTS

The experimental design of this laboratory study provided for an assessment of the acute effects of exposure to dredge materials on selected organisms in a situation that simulated conditions related to a dredging operation. Solid phase tests consisted of sediment held undisturbed under dilution water to approximate conditions prior to or immediately after dredging operations, and particulate phase tests consisted of exposing organisms to highly concentrated suspended particulates to simulate "worst case" conditions during hydraulic dredging operations.

Sediment

Sediment samples were collected by personnel of the St. Paul District Corps of Engineers from 10 sites on the Upper Mississippi River (Table 1). Sediment was collected with a Ponar dredge and transported on ice in stainless steel containers to the National Fishery Research Laboratory at La Crosse, Wisconsin. Two sediment samples were delivered to the laboratory every 2 weeks over a period from June 3 to July 30, 1980. Four containers of sediment were collected from each site. Upon receipt of the sediment samples, the material wes homogenized in a Hobart food mixer equipped with stainless steel paddle and bowl. Portions of the homogenate were then taken for solid phase tests, particulate phase

tests, and chemical anlayses; the remaining sediment was stored in polyethylene tanks at 4°C.

Test Organisms

Aquatic invertebrates were collected from the wild or cultured at the laboratory. All specimens were held in favorable culture conditions prior to exposures to the sediment. No group was used if 10% or more died during a quarantine period or otherwise appeared unhealthy. Organisms were considerd healthy if they fed and thrived under culture conditions. Scuds (*Gammarus pseudolimnaeus*) and snails (*Physa gyrina*) were collected with a sweep net from a feeder spring on the Kickapoo River near Avalanche, Wisconsin. Crayfish (*Procambarus* sp.) were obtained from the Genoa National Fish Hatchery. Mayflies (*Hexagenia* sp.) were cultured from eggs obtained from Pool 7 (Lake Onalaska, River Mile 703-708) during the 1979 summer emergence. Midge (*Chironomus tentans*) were obtained from Dr. Joseph Kawatski, Viterbo College, La Crosse, Wisconsin. Fawnfoot mussels (*Truncilla donaciformis*) were collected, with long handled nets by wading or standing in a boat, from the Upper Mississippi River (River Mile 722). Fingernail clams (*Sphaerium* sp.) were collected using sweep nets from Pool 7 (Lake Onalaska, River Mile 703-708). Fathead minnows (*Pimephales promelas*) and channel catfish (*Ictalurus punctatus*) were cultured at the La Crosse National Fishery Research Laboratory. Organisms were exposed in vessels based on their size and compatability with other species. Fathead minnows and channel catfish were grouped as were crayfish and fawnfoot mussels. Both groups were exposed in 5-gallon jars. Midges, mayflies, and fingernail clams were exposed as a group; so were snails and scuds. These animals were exposed in 1-gallon glass jars.

Test Procedures

Acute toxicity tests on the sediment samples were performed in two phases--a solid phase and suspended particulate phase. Sediment for solid phase exposures was placed in 1-and 5-gallon glass jars and reconstituted well water was added to yield a ratio of 4" of water per 1" of sediment. Care was taken when adding the water to avoid disturbing or partitioning of the sediment. Exposure water was prepared by reconstituting deionized well water according to methods outlined by the Committee on Methods for Toxicity Tests with Aquatic Organisms (1974) to approximate water chemistry conditions found in the Upper Mississippi River (pH, 7.6-8.0; total hardness expressed in mg/L as $CaCO_3$, 160-180). Solutions in the test vessels were allowed to settle for 12 hours before introducing test organisms. Aeration of test solutions was provided as necessary to maintain the oxygen concentration needed to support the test organisms, and was kept to a minimum to avoid creating turbulence that would disturb the sediment. Water temperatures were maintained at 17°C by immersing test vessels in water baths. Each exposure was duplicated and one-half of the water volume in each test vessel was replaced daily for 96 hours as specified in the contract. Dissolved oxygen, pH, turbidity, and suspended solids readings were taken daily. After 96 hours, the test vessel contents were washed through a fine mesh screen, and survival information for the test organisms was recorded.

Sediment suspensions for particulate phase tests were prepared daily by vigorously mixing sediment with reconstituted well water at a ratio of four parts water to one part sediment. The suspension was vigorously mixed in a Hobart mixer for 30 minutes. After a 5-minute settling period, the supernatant was carefully decanted into 100-liter polyetnylene

tanks. This suspension was considered to typify a system of 100% suspended particulate medium. The suspension was maintained by vigorous aeration and quickly added to the test vessels where the water was aerated prior to the addition of the test organisms. Aeration was also provided during the exposures to maintain suspensions of particulate materials. All exposures were set up in quadruplet; two were assessed for mortality at 24 hours of exposure and two at 96 hours. Of those for 96-hour exposures, one-half of the volume was replaced daily with freshly prepared 100% suspended particulate matter for 4 days (96 hours). Water temperatures were maintained at 17°C by immersing test vessels in water baths. Exposure media were monitored daily for dissolved oxygen, pH, turbidity, and suspended solids. After 96 hours the contents of the exposure vessels were washed through a fine mesh screen and survival-mortality data for test organisms were recorded. In some instances, the number of organisms recovered was less than that added initially. To allow for "worst case situation", the missing animals were recorded as mortalities.

Tests on suspended particulates that resulted in greater than 20% mortality for a species were further delineated using dilutions of the 100% suspended particulate medium. Organisms were exposed to the undiluted particulate (100% suspended particulates) and suspensions containing 90, 75, 50, 25, and 0% of the undiluted particulate medium. The 0% exposure was a control test. The LC_{50}'s and 95% confidence intervals were calculated according to procedures of Litchfield and Wilcoxon (1949) for those groups of exposed organisms in which substantial mortality occurred among exposed organisms and where control organism survival was 80% or greater. Procedures for batch replacement

and chemical analyses and for recording temperature and survival/mortality data were the same for the particulate and solid phase tests.

Control organisms were maintained in reconstituted test water with no sediment. One group of controls was aerated, and one group was not aerated to assess any effects that aeration might produce on test organisms.

RESULTS

Nine organisms that represent species found in the Upper Mississippi River were exposed to sediment samples from 10 sites where maintenance would be expected based on past dredging records. Bioassay exposures were conducted in two phases: (1) a suspended particulate phase which approximated the "worst case" conditions of suspended materials which might develop conditions during and following hydraulic dredging, and (2) a solid phase which simulated pre-dredge conditions or conditions following settling immediately after dredging.

Particulate Phase Exposures

Sediments from the following sites were predominantly sand and produced little or no mortality: Read's Landing, Truedale Slough, West Newton, Somerfield Island, Island 58, Grey Cloud Slough, and Below Cudahy, Wisconsin (Tables 2-7). An exception was mayfly nymphs and midge larvae exposed to sediment from Truedale Slough. Results of preliminary exposures were erratic for both organisms as well as control organisms (Table 8). We reexposed these organisms to the 100% particulate phase solution and also to concentrations of 90, 75, 50, and 25% to establish a concentration-response gradient. With mayfly nymphs, survival rates were 80-100% at all concentrations, i.e., no mortality was related to the sediment (Table 9). Midge survival was erratic at all concentrations,

however, the controls survived well (90-100%). We were unable to establish a concentration correlated response curve, possibly because the midge culture may have been approaching emergence. If so, the vigorous aeration coupled with the abrasive nature of the soil particles may have been more than the midge larvae could tolerate.

Sediment samples that contained a high percentage of silt, clay, and colloidal materials produced the most significant toxic effect. Sediment from the Winona small boat harbor produced 54 and 73% mortality among midge larvae in 1-day exposures (Table 10). However, the observed mortality figures are considered questionable as numerous live midge larvae were present in the sample when it arrived. All observed larvae were assessed in the mortality and survival figures, and it is possible that some midges in the original sample were killed during the sediment mixing procedure. The 4-day test results support this conclusion because 90% of the animals survived.

Samples from the Red Wing Commercial Harbor and St. Paul Barge Terminal were the only ones considered toxic to aquatic organisms. Suspended particulate material from the Red Wing Commercial Harbor produced substantial mortality among crayfish, fathead minnows, and channel catfish (Table 11). Mayfly nymphs, midge larvae, snails, and fingernail clams were also affected, but erratic mortality among control groups of these organisms or survival rates very close to our minimum acceptability limits (80%) led us to to believe that the mortality was not directly due to the sediment.

Delineation tests confirmed the preliminary results. All organisms of four species survived the exposures or, as with snails, the mortality among exposed individuals was essentially the same as that among controls

(Table 12). Mortality among crayfish, fathead minnows, and channel catfish was definitely associated with the sediment; survival increased as particulate phase material was diluted. For instance, survival of crayfish ranged from 40% in the undiluted test media to 100% in the dilution containing 25% of the undiluted media. The 96-hour LC_{50}'s (concentration calculated to produce 50% mortality) and 95% confidence intervals are as follows:

Crayfish	84.5%	(70.7-101)
Fathead minnow	107%	(85.2-134)
Channel catfish	60.0%	(51.3-70.2)

The LC_{50} for fathead minnow is obviously an extrapolated value because less than 50% mortality occurred in the undiluted suspension. The values for crayfish and channel catfish are more meaningful because more than 50% mortality resulted in the undiluted suspension.

The St. Paul Barge Terminal sample produced mortalities exceeding 20% among crayfish, snails, fingernail clams, and fathead minnows (Table 13). The observed mortalities did not exceed 50% for any species.

Delineation of the particulate phase media showed decreased survival of crayfish at suspended particulate concentrations of 50% or greater (Table 14). Survival of fingernail clams was decreased at the 100% concentrations, but acceptable survival occurred at the 90% level. Fathead minnow survival was decreased at concentrations of 75% or greater; snails were not affected in the delineation tests. The 96-hour LC_{50}'s and 95% confidence intervals are as follows:

Crayfish	86%	(69.5-106)
Fingernail clams	117%	(95.4-144)
Fathead minnows	163%	(116-229)

Again, values for fingernail clams and fathead minnows were extrapolated from the mortality regression and represent theoretical values because greater than 50% mortality did not result in the undiluted suspension.

Among the 10 samples sites, Red Wing Commercial Harbor and St. Paul Barge Terminal were the only two samples that produced enough toxicity to justify delineation. Both samples contained more colloidal and clay size particles than the other sample sties, and chemical contaminants were also higher in those samples. Toxicity of the other sites containing larger particle size sediment was essentially nondetectable.

Solid Phase Exposures

In contrast to the results from particulate phase exposures, solid materials produced no mortalities that could be related to possible contaminants (Tables 15-24). Scuds, crayfish, fawnfoot mussels, and fingernail clams had good survival in all solid phase exposures. Results of tests with mayfly nymphs, midge larvae, and snails were inconsistent. For these organisms, the mortality in control lots was equal to or greater than the mortality among exposed organisms. Exposures of these species provided erratic results in both solid and particulate phase tests. However, because mortalities among control and exposed organisms were not substantially different, the sediment was not considered to be toxic.

Chemical characteristics of the particulate phase test solutions were fairly constant considering the complexity of the mixing, daily batch replacement, and aeration procedures used (Appendix I). A problem encountered in some of the particulate phase tests involved the increasing suspended solid concentrations due to daily replacement of one-half of the

sample volume as the test progressed. The gradual increase in concentrations of suspended solids was apparently related to the settling of some of the particulate matter during the day between batch replacements. During the replacement procedure, some of this "pseudosettled" material was probably resuspended. This occurrence was reflected as an increased concentration of suspended particulate matter when measured 1 hour after each batch replacement. This conclusion was further substantiated by turbidity data determined before and after each batch replacement. Generally, turbidity concentrations increased from day 1 through ensuing days, but during each day, the turbidity decreased with the passage of time until the next batch replacements. Dissolved oxygen and pH remained relatively constant throughout the tests.

Chemical and physical characteristics of the solid phase test solutions were slightly more variable than those of the particulate phase solutions. The pH of the solid phase test solution was generally more acidic after the 12-hour settling period than it was on subsequent days after aeration and the introduction of test organisms. Dissolved oxygen concentrations in solid phase solutions were lower after the settling period probably due to the oxygen demand of the sediment. Turbidity and suspended solid concentrations were relatively stable in most solid phase solutions. However, we did note that crayfish activity in the test vessels increased the turbidity and concentration of suspended solids in tests involving sediment which contained significant amounts of fine particulate matter.

Chemical characteristics of delineative test solutions prepared by the dilution of 100% particulate matter with reconstituted well water were very comparable for pH and dissolved oxygen (Appendix II) throughout the

4-day test period. Turbidity and suspended solids readings were somewhat variable from day to day, but the 4-day averages of the various dilutions compared favorably with the intended (calculated) concentrations.

DISCUSSION

Sediment samples from the 10 sites can be characterized into two types: (1) predominantly sand, and (2) fine sand with substantial amounts of silt, clay, and colloidal materials. Biological activity in the particulate phase exposures was related to the type of sediment material. Samples which contained predominantly sand were essentially nontoxic, and samples containing substantial amounts of silt, clay, and colloidal material often produced a toxic effect.

Results from the chemical analyses reported in this study suggest that samples from the Red Wing Commercial Boat Harbor and the St. Paul Barge Terminal were the most contaminated. The Prater and Anderson (1977) index for classifying sediments indicate that materials from both sites were heavily polluted. Results of the biological activity tests parallel the analytical results in that samples from these sites also displayed the greatest contamination among the 10 samples.

The survival of control organisms was assessed in aerated and unaerated vessels in attempts to detect differences in mortality due to the turbulence produced by aeration. We detected no differences in survival rates for aerated versus unaerated control lots of organisms. In some instances, survival was best in aerated vessels while, in other cases, the opposite occurred. However, control vessels contained no sediment, and the poor survival of mayfly nymphs and midge larvae may have been caused by the lack of a suitable substrate.

The erratic mortality among snails may have been associated with the age, life stage, or physical condition of the specimens. Since these animals were collected from nature, there was no way to determine the age of individuals even though specimens used were similar in size. Additional studies using laboratory cultured organisms may provide more consistent results.

PART II

METHODS FOR CHEMICAL CHARACTERIZATION

Sediment samples were homogenized and analyzed for particle size by sieving and by the hydrometer method (ASTM 1979). Sieving was carried out with a series of stainless steel sieves on a Soil Test sieve shaker. Dispersion of the sediment sample for the hydrometer test was obtained with a Soil Test stirrer and a dispersion cup.

Suspended particulate solutions were prepared by vigorously mixing a 1:4 (volume:volume) ratio of homogenized sediment and reconstituted water (160-180 mg/L total hardness as $CaCO_3$) for 30 minutes. After 5 minutes settling time, the supernatant (suspended particulates) was siphoned off. The suspended particulate fraction was divided, and half of this sample was centrifuged to remove most of the heavy particulate material and then filtered through millipore filters (0.45 μm) to obtain the elutriate (liquid phase) sample.

Aliquots of the sediment for the solid, suspended particulate, and liquid phases were analyzed in duplicate for volatile solids, chemical oxygen demand (COD), and biochemical oxygen demand (BOD) following standardized procedures (American Public Health Association 1976; U.S. Environmental Protection Agency 1979). Following acid digestion, samples were analyzed for cadmium, chromium, copper, lead, iron, nickel, and

zinc using a Model 560 Perkin-Elmer atomic absorption spectrophotometer equipped with graphite furnace. Cold vapor technique was used for mercury analysis (American Public Health Association 1976).

Analyses for ammonia nitrogen were made using a Model 40? Orion specific ion meter. Oil and grease fractions were determined gravimetrically following soxalet extraction (American Public Health Association 1976).

Duplicate analyses of bulk sediment samples for nitrite nitrogen and nitrate nitrogen were made using the methods of soil analysis described by Bremner (1965). Analyses for ortho and total phosphate were done according to the methods of Olsen and Dean (1965), pH was measured by the method of Peech (1965).

Many water analysis procedures recommend filtration of highly turbid samples prior to analysis. In our study, this would have altered the suspended particulate sample, essentially converting it into another elutriate sample. Therefore, the suspended particulate samples were analyzed by the procedures referenced above for solid phase analysis.

Procedures used for analysis of the liquid phase are those outlined for water by the American Public Health Association (1976).

Analyses for residues of PCB's (as Aroclor 1254), DDT, DDD, DDE, dieldrin, endrin, and chlordane were made according to methods developed by Ted Schwartz of the Columbia National Fishery Research Laboratory, Columbia, Missouri, (personal communication). The procedure involved blending sediment with anhydrous sodium sulfate followed by column extraction with methylene chloride. The liquid phase was extracted with methylene chloride in separatory funnels. Florisil and silica gel columns were used for sample cleanup. Sulfur interferences were removed by

reaction with copper metal. Cleaned-up samples were then analyzed against reference pesticide standards on Varian 3700 and Tracor MT-220 gas chromatographs equipped with electron capture detection. Operating conditions for the Varian 3700 were as follows: 6 ft X 2 mm glass column packed with 1.5% OV-17 and 1.95% QF-1 on 80-100 mesh Chromosorb W-HP; column temperature, 190°C; detector temperature, 370°C; injector temperature, 220°C; nitrogen carrier gas flow, 32 mL/min; electrometer setting, 4 X 10^{-11} AFS deflection on a 1 mV recorder. Operating conditions for the Tracor MT-220 were as follows: 6 ft X 4 mm glass column packed with 3% OV-17 on 80-100 mesh Chromosorb W-HP; column temperature, 200°C; detector temperature, 300°C; injector temperature, 270°C; nitrogen carrier gas flow, column-40 mL/min, scavenge-40 mL/min; electrometer setting, 1.6 X 10^{-9} AFS deflection on a 1 mV recorder.

Duplicate samples of the reconstituted dilution water used in making the suspended particulate and liquid phases were also analyzed for all of the listed chemicals. Results of analyses of sediment samples are reported on the basis of dry weights of sediments. Results of analyses of the suspended particulates, elutriate, and reconstituted water are reported on the basis of concentration per liter.

There was a shortage of sample material from the Winona Small Boat Harbor site so the analyses of the solid and suspended particulate phases for oil and grease could not be completed for that site (Table 63).

The column extraction procedure for the solid phase and solvent partitioning of the liquid phase were found to be inappropriate for extracting chlorinated hydrocarbons from the suspended particulate phase. Therefore, concentrations of chlorinated hydrocarbons in the particulate phase were not determined.

RESULTS AND DISCUSSION
FOR CHEMICAL CHARACTERIZATION

Hydrometer particle size measurements were recorded in specific gravity units (Tables 25-34). The percent term refers to the percentage of soil remaining in suspension at the level at which the hydrometer measured the density of suspension. Stokes' law was used to calculate the diameter of particles (in microns) that settled from the surface of the suspension at the beginning of the sedimentation to the level at which the hydrometer was measuring the density of the suspension (ASTM 1979). The hydrometer test was useful in determining the percentage of the sediment that was made up of silt, clay, or colloid. Sieving was used to segregate various sizes of sand particles (Tables 35-44). The combination of these two techniques was then used to determine particle size classification of each sediment sample (Tables 45-54). Particle size distributions of each of the 10 sites show that most of the sediment samples were predominantly sand with samples from Red Wing Commercial Harbor, St. Paul Barge Terminal, and Winona Small Boat Harbor containing large amounts of silt and clay (Fig. 1).

Reconstituted water used in preparing the suspended particulate and elutriate phases was composed of deionized water and ACS reagent grade inorganic salts. The average pH of the dilution water was 8.26. Concentrations of none of the other characteristics were above minimum detectable limits (Table 55).

None of the pH's for any phase of the samples fell outside the range of 7-9. The average pH was about 7.9. The pH of the liquid phases was generally higher than that of the particulate phases, which was usually slightly higher than that of the solid phases (Tables 56-65).

There was generally good agreement between replicate anlayses indicating the samples were well homogenized before subsampling (Tables 25-65). In chemical characterization, concentrations were generally largest for solid phase samples, and the values for suspended particulate samples were generally larger than the liquid phase samples (Tables 56-65). This was expected since progressively more of the sediment material was removed in preparation of the suspended particulate and liquid phase samples. The relationship was particularly evident in analyses for COD, BOD, phosphates, oil and grease, and some of the metals such as cadmium, chromium, zinc, and iron. Consequently, in a dredging operation, the majority of contaminants found in the tested sediments generally would remain associated with the sediments and would not be available to aquatic organisms unless they are water extractable. Vigorous treatment such as acid digestion would be required to liberate most of the materials.

Such lack of release of contaminants from sediments has been widely documented by studies using the standard elutriate test which usually involves mixing for 30 minutes and settling for 60 minutes (Brannon et al. 1976a; Brannon et al. 1976b; Burks and Engler 1978; Gambrell et al. 1980). In this study, only 5 minutes settling time was used during preparation of the elutriate to simulate a "worse case" situation. Very little of the contaminants was released. None of the concentrations observed in the liquid phase, by themselves, would be acutely toxic to aquatic organisms with several possible exceptions. The exceptions included the levels of ammonia nitrogen found in the samples from the St. Paul Barge Terminal (Table 57) and Red Wing Commercial Harbor (Table 59) and several samples with potentially hazardous concentrations of cadmium (Tables 56-61, 63, 65) and zinc (Tables 57, 58, 61, 62, 64, 65). Burks and Engler (1978) also

reported the water solubility and release of ammonia from sediments. Brannon et al. (1976b) reported that the release of ammonia concentrations in standard elutriate tests exceeded EPA water quality standards for aquatic life.

Residues of PCB's (as Aroclor 1254) were observed in all sediment samples. However, the concentration in several samples (Tables 56, 60, 61, 62) was less than that which could be accurately quantified (<1.00 ng/g). In every case where only trace amounts were observed, the sediment particle size was classified as being predominantly medium sand with essentially no particles smaller than fine sand (74-425 μm). This inverse relationship between particle size and contaminant concentration was well correlated for most parameters examined. Sediments from the St. Paul Barge Terminal, Red Wing Commercial Harbor, and Winona Small Boat Harbor, for example, were characterized as consisting of large proportions of silt and clay (Tables 46, 48, 52) and all contained significantly greater concentrations of contaminants than samples which were predominantly sand. Grimwood and McGhee (1979) also observed that the adsorption of dissolved materials on sediments is associated with the finer particles, particularly clays (<5 μm).

The sediment sample from Red Wing Commercial Harbor (Table 59) was the only sample where DDE and endrin were confirmed. That site also contained residues of DDT, DDD, dieldrin, and chlordane. Residues of these chlorinated hydrocarbons were usually not found in sediments which were predominantly sand (Tables 56, 58, 60, 61, 62, 64); the exception was the sample from below Cudahy which contained a small amount of DDD and chlordane (Table 65). However, this sample was partially composed of silt and clay size particles (Table 54).

Prater and Anderson (1977) compiled a list of the ranges of concentrations of contaminants they found in sediments and used the list to classify sediments as nonpolluted, moderately polluted, or heavily polluted. Based on their classification system, the sediment sample from Red Wing Commercial Harbor was heavily polluted with volatile solids, zinc, ammonia, phosphate, nickel, and chromium, and moderately polluted with iron and COD (Table 59). The only other sample that was heavily polluted according to their classification system was from the St. Paul Barge Terminal. This site was contaminated with zinc and was also moderately polluted with phosphate, nickel, and chromium (Table 57). Nickel and chromium were ubiquitous contaminants. The only samples not polluted with nickel to some degree were from Read's Landing (Table 56) and Truedale Slough (Table 58). Read's Landing was the only site not polluted with chromium.

Analytical Quality Control

Quality assurance for the analytical procedures used in this study was provided by several integrated programs. Control standards of water, wastewater, metals, and pesticides for most of the characteristics we currently monitor are analyzed on a regular basis. Results of analyses are regularly checked against the manufacturer's standard values. If the result of an analysis for any characteristic falls outside the acceptable range, steps are taken to evaluate the cause of the discrepancy and to correct the problem. Quality assurance standards of potable water, wastewater, metals, and pesticides were obtained from Environmental Resource Associates, 120 East Sauk Trail, South Chicago Heights, Illinois 60411. Standards for minerals, nutrients, demands, and trace metals were obtained from the Environmental Protection Agency, Cincinnati, Ohio.

Analyses of replicate samples and the technique of known addition standards are used to verify precision and accuracy of analytical procedures. Additional quality assurance is provided by "splitting" samples with a local water quality laboratory (Davy Water Quality Laboratory, La Crosse, Wisconsin).

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Table 1. Upper Mississippi River sediment sample sites -- 1980.

Site name	River mile	Date collected
St. Paul Barge Terminal	836.6-837.8	June 3
Read's Landing	761.8-763.8	June 3
Red Wing Commercial Harbor	791.4	June 17
Truedale Slough	808.2-808.7	June 17
West Newton	747.2-748.2	July 1
Somerfield Island	742.6-743.9	July 1
Winona Small Boat Harbor	726.0	July 15
Island 58	734.0-735.2	July 15
Below Cudahy	831.0-832.4	July 29
Grey Cloud Slough	827.5-828.3	July 29

Table 2. Survival of selected aquatic organisms exposed to sediment from Read's Landing for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	90	80	100	100	100	90	90	100	100	100
Crayfish *Procambarus* sp.	80	100	80	100	---	---	---	---	100	100	90	80
Mayfly *Hexagenia* sp.	100	100	80	80	90	90	90	80	100[a]	100	80	80
Midge *Chironomus tentans*	80	100	80	70	90	100	90	80	100[a]	100	100	60
Snail *Physa gyrina*	90	100	70	60	100	90	80	80	100	100	80	80
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam *Sphaerium* sp.	100	100	80	100	100	100	100	90	100	100	70	90
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	90
Channel catfish *Ictalurus punctatus*	100	100	100	100	---	---	---	---	100	100	100	100

[a]Mayfly nymphs and midge larvae existed in the original sample; those specimens were included in the data.

Table 3. Survival of selected aquatic organisms exposed to sediment from West Newton for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	90	90	90	90	100	100	90	90	100	100	80	80
Crayfish *Procambarus* sp.	90	100	90	90	---	---	---	---	100	100	100	100
Mayfly *Hexagenia* sp.	100	100	80	90	100	100	70	90	80	90	100	100
Midge *Chironomus tentans*	100	100	70	70	100	100	70	90	90	80	80	80
Snail *Physa gyrina*	90	90	90	90	100	100	80	100	90	100	90	90
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam *Sphaerium* sp.	100	90	90	90	100	100	80	100	100	100	70	90
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish *Ictalurus punctatus*	100	100	100	100	---	---	---	---	100	100	100	100

Table 4. Survival of selected aquatic organisms exposed to sediment from Somerfield Island for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	80	90	90	90	90	90	100	90	100	70
Crayfish *Procambarus* sp.	100	100	100	100	---	---	---	---	100	100	100	100
Mayfly *Hexagenia* sp.	100	100	90	90	100	100	100	100	90	100	100	100
Midge *Chironomus tentans*	100	100	70	70	70	90	70	90	100	90	80	80
Snail *Physa gyrina*	100	100	90	90	80	100	80	100	100	90	90	90
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam *Sphaerium* sp.	100	90	90	80	90	90	90	90	90	100	90	70
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish *Ictalurus punctatus*	100	100	100	90	---	---	---	---	100	100	100	100

Table 5. Survival of selected aquatic organisms exposed to sediment from Island 58 for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	90	100	90	90	100	90	80	90	90	100	100	100
Crayfish *Procambarus* sp.	100	100	100	100	---	---	---	---	100	100	100	100
Mayfly *Hexagenia* sp.	90	90	90	90	90	100	90	80	100	100	80	90
Midge *Chironomus tentans*	100	100	100	80	90	90	60	80	100	90	100	100
Snail *Physa gyrina*	100	100	100	80	90	100	70	60	100	100	100	100
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam *Sphaerium* sp.	100	100	100	100	100	100	100	100	100	100	90	100
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish *Ictalurus punctatus*	100	100	100	100	---	---	---	---	100	100	100	100

Table 6. Survival of selected aquatic organisms exposed to sediment from Grey Cloud Slough for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	100	100	100	100	80	100	90	90	90	90
Crayfish *Procambarus* sp.	100	100	100	100	---	---	---	---	100	100	100	100
Mayfly *Hexagenia* sp.	100	100	70	100	90	100	60	80	100	100	100	90
Midge *Chironomus tentans*	100	100	70	100	90	100	80	50	100	100	80	60
Snail *Physa gyrina*	100	100	60	90	100	100	60	40	90	100	80	70
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam *Sphaerium* sp.	100	100	80	100	100	100	50	100	100	100	90	100
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish *Ictalurus punctatus*	100	100	90	100	---	---	---	---	100	100	100	100

Table 7. Survival of selected aquatic organisms exposed to sediment from below Cudahy for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud _Gammarus pseudolimnaeus_	100	100	100	100	100	100	90	80	100	100	100	90
Crayfish _Procambarus_ sp.	100	100	100	100	---	---	---	---	90	100	100	100
Mayfly _Hexagenia_ sp.	100	100	90	100	100	100	90	90	90	100	100	90
Midge _Chironomus tentans_	100	100	90	80	60	80	50	80	100	100	100	100
Snail _Physa gyrina_	100	100	60	90	100	100	80	50	100	80	100	90
Fawnfoot clam _Truncilla donaciformis_	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam _Sphaerium_ sp.	100	100	80	100	100	100	100	90	100	100	70	100
Fathead minnow _Pimephales promelas_	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish _Ictalurus punctatus_	100	100	100	100	---	---	---	---	100	100	90	90

Table 8. Survival of selected aquatic organisms exposed to sediment from Truedale Slough for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud _Gammarus pseudolimnaeus_	80	80	80	80	100	100	100	100	100	100	70	90
Crayfish _Procambarus_ sp.	90	100	90	100	---	---	---	---	90	100	80	90
Mayfly _Hexagenia_ sp.	80	60	60	80	70	80	70	80	100	80	60	50
Midge _Chironomus tentans_	70	70	70	70	50	100	50	100	70	80	70	80
Snail _Physa gyrina_	100	100	100	100	100	90	100	90	100	90	100	90
Fawnfoot clam _Truncilla donaciformis_	100	100	100	100	---	---	---	---	100	100	100	100
Fingernail clam _Sphaerium_ sp.	100	90	100	90	100	70	100	70	100	100	90	100
Fathead minnow _Pimephales promelas_	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish _Ictalurus punctatus_	100	100	100	100	---	---	---	---	100	100	100	100

Table 9. Delineation of particulate phase tests with sediment from Truedale Slough in reconstituted water at 17°C.

Composition (%) and species	Percent survival among two groups of 10 organisms each for 4 days	
	A	B
Mayfly nymphs *Hexagenia* sp.		
100	90	90
90	100	100
75	80	100
50	100	100
25	100	90
Control[a]	90	90
Midge larvae *Chironomus tentans*		
100	50	50
90	60	50
75	70	40
50	30	60
25	30	60
Control[a]	100	90

[a]Dilution water only.

Table 10. Survival of selected aquatic organisms exposed to sediment from Winona Small Boat Harbor for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	100	80	100	100	90	90	100	100	100	100
Crayfish *Procambarus* sp.	100	100	100	100	---	---	---	---	100	100	90	90
Mayfly *Hexagenia* sp.	100	100	90	100	100	100	80	90	100	90	100	100
Midge *Chironomus tentans*	90	100	90	80	90	90	90	70	54[a]	73[a]	90	90
Snail *Physa gyrina*	100	80	100	70	90	100	90	100	100	100	100	100
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	100	90
Fingernail clam *Sphaerium* sp.	100	100	70	100	100	100	100	100	100	100	100	100
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	100	100	100	100
Channel catfish *Ictalurus punctatus*	100	100	100	90	---	---	---	---	100	90	100	80

[a]Mayfly nymphs and midge larvae existed in the original sample; those specimens were included in the data.

Table 11. Survival of selected aquatic organisms exposed to sediment from Red Wing Commercial Harbor for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	100	100	90	80	90	80	100	90	80	80
Crayfish *Procambarus* sp.	100	100	100	100	---	---	---	---	80	70	50	50
Mayfly *Hexagenia* sp.	60	80	60	80	60	30	60	30	70	83[a]	10	20
Midge *Chironomus tentans*	50	60	50	60	100	100	100	100	100	80	70	60
Snail *Physa gyrina*	90	90	90	90	90	100	90	100	100	100	70	70
Fawnfoot clam *Truncilla donaciformis*	100	100	100	100	---	---	---	---	100	100	90	100
Fingernail clam *Sphaerium* sp.	90	100	90	100	80	90	80	90	100	100	60	70
Fathead minnow *Pimephales promelas*	100	100	100	100	---	---	---	---	70	90	90	60
Channel catfish *Ictalurus punctatus*	100	100	100	100	---	---	---	---	30	40	50	0

[a]Mayfly nymphs and midge larvae existed in the original sample; those specimens were included in the data.

Table 12. Delineation of particulate phase sediment tests from Redwing Commercial Boat Harbor in reconstituted water at 17°C.

Species and media composition (%)	Percent survival among two groups of 10 organisms each for 4 days A	B
Crayfish *Procambarus* sp.		
100	50	30
90	40	50
75	60	60
50	80	90
25	100	100
Control[a]	100	100
Mayfly nymphs *Hexagenia* sp.		
100	90	90
90	90	90
75	60	90
50	100	100
25	100	100
Control[a]	80	90
Midge larvae *Chironomus tentans*		
100	90	80
90	90	90
75	90	90
50	90	80
25	100	100
Control[a]	90	90

(more)

Table 12. (cont'd)

Species and media composition (%)	Percent survival among two groups of 10 organisms each for 4 days A	B
Snail *Physa gyrina*		
100	70	60
90	80	80
75	90	70
50	90	80
25	100	100
Control[a]	60	90
Fingernail clam *Sphaerium sp.*		
100	80	90
90	100	90
75	90	80
50	90	100
25	90	80
Control[a]	100	100
Fathead minnow *Pimephales promelas*		
100	60	50
90	60	70
75	60	80
50	70	80
25	100	100
Control[a]	100	100

(more)

Table 12. (cont'd)

Species and media composition (%)	Percent survival among two groups of 10 organisms each for 4 days	
	A	B
Channel catfish *Ictalurus punctatus*		
100	0	0
90	0	30
75	20	30
50	80	50
25	100	100
Control[a]	100	100

[a]Dilution water only.

Table 13. Survival of selected aquatic organisms exposed to sediment from St. Paul Barge Terminal for 1- and 4-day exposures in hard water at 17°C in a particulate phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each											
	Control (aerated)				Control (unaerated)				Exposed			
	1 day		4 days		1 day		4 days		1 day		4 days	
	A	B	A	B	A	B	A	B	A	B	A	B
Scud _Gammarus pseudolimnaeus_	100	80	100	80	100	100	70	80	100	100	90	100
Crayfish _Procambarus_ sp.	90	100	90	80	---	---	---	---	60	80	80	60
Mayfly _Hexagenia_ sp.	100	100	90	100	100	80	100	70	100	100	90	100
Midge _Chironomus tentans_	100	100	60	60	100	100	100	100	100	100	90	90
Snail _Physa gyrina_	100	100	70	80	100	100	60	90	100	100	70	70
Fawnfoot clam _Truncilla donaciformis_	100	100	100	100	---	---	---	---	100	100	70	90
Fingernail clam _Sphaerium_ sp.	100	100	90	100	100	100	100	100	90	100	50	70
Fathead minnow _Pimephales promelas_	100	100	100	100	---	---	---	---	60	80	80	50
Channel catfish _Ictalurus punctatus_	100	100	100	100	---	---	---	---	100	100	90	90

Table 14. Delineation of particulate phase tests with sediment from the St. Paul Barge Terminal in reconstituted water at 17°C.

Species and media composition (%)	Percent survival among two groups of 10 organisms each for 4 days A	B
Crayfish *Procambarus* sp.		
100	40	---
90	40	---
75	70	---
50	90	---
Control[a]	90	---
Snail *Physa gyrina*		
100	90	90
90	100	90
75	90	90
50	80	90
Control[a]	100	80
Fingernail clams *Sphaerium* sp.)		
100	60	60
90	70	100
75	70	90
50	90	90
Control[a]	90	100

(more)

Table 14. (cont'd)

Species and media composition (%)	Percent survival among two groups of 10 organisms each for 4 days	
	A	B
Fathead minnow *Pimephales promelas*		
100	40	90
90	70	60
75	100	90
50	90	90
Control[a]	100	100

[a]Dilution water only.

Table 15. Survival of selected aquatic organisms exposed to sediment from Read's Landing for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	90	80	100	90	90	80
Crayfish *Procambarus* sp.	80	100	---	---	90	100
Mayfly *Hexagenia* sp.	80	80	90	80	70	100
Midge *Chironomus tentans*	80	70	90	80	60	50
Snail *Physa gyrina*	70	60	80	80	100	90
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	80	100	100	90	70	100

Table 16. Survival of selected aquatic organisms exposed to sediment from Truedale Slough for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each: Control (aerated) A	Control (aerated) B	Control (unaerated) A	Control (unaerated) B	Exposed A	Exposed B
Scud *Gammarus pseudolimnaeus*	80	80	100	100	90	100
Crayfish *Procambarus* sp.	90	100	---	---	100	100
Mayfly *Hexagenia* sp.	80	60	70	80	10	40
Midge *Chironomus tentans*	70	70	50	100	30	60
Snail *Physa gyrina*	100	100	100	90	90	100
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	100	90	100	70	80	70

Table 17. Survival of selected aquatic organisms exposed to sediment from West Newton for 4-days in hard water at 17°C in a solid-phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	90	90	90	90	100	80
Crayfish *Procambarus* sp.	90	90	---	---	100	100
Mayfly *Hexagenia* sp.	80	90	70	90	100	100
Midge *Chironomus tentans*	70	70	70	90	60	70
Snail *Physa gyrina*	90	90	80	100	70	70
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	90	90	80	100	80	90

Table 18. Survival of selected aquatic organisms exposed to sediment from Somerfield Island for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each: Control (aerated) A	Control (aerated) B	Control (unaerated) A	Control (unaerated) B	Exposed A	Exposed B
Scud *Gammarus pseudolimnaeus*	80	90	90	90	100	90
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	90	90	100	100	100	90
Midge *Chironomus tentans*	70	70	70	90	90	80
Snail *Physa gyrina*	90	90	80	100	80	60
Fawnsfoot clam *Truncilla donaciformis*	[illegible]	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	90	80	90	90	80	80

Table 19. Survival of selected aquatic organisms exposed to sediment from Island 58 for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	90	90	80	90	100	80
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	90	90	90	80	100	100
Midge *Chironomus tentans*	100	80	60	80	90	80
Snail *Physa gyrina*	100	80	70	60	100	100
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	100	100	100	100	90	100

Table 20. Survival of selected aquatic organisms exposed to sediment from Grey Cloud Slough for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	80	100	90	90
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	70	100	60	80	90	80
Midge *Chironomus tentans*	70	100	80	50	80	90
Snail *Physa gyrina*	60	90	60	40	50	80
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	80	100	50	100	100	90

Table 21. Survival of selected aquatic organisms exposed to sediment from below Cudahy for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	90	80	90	70
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	90	100	90	90	100	90
Midge *Chironomus tentans*	90	80	50	80	100	100
Snail *Physa gyrina*	60	90	80	50	100	100
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	80	100	100	90	90	80

Table 22. Survival of selected aquatic organisms exposed to sediment from Winona Small Boat Harbor for 4 days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	80	90	90	100	100
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	90	100	80	90	90	80
Midge *Chironomus tentans*	90	80	90	70	100	90
Snail *Physa gyrina*	100	70	90	100	100	100
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	70	100	100	100	100	100

Table 23. Survival of selected aquatic organisms exposed to sediment from Red Wing Commercial Harbor for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	100	90	80	100	100
Crayfish *Procambarus* sp.	100	100	---	---	100	100
Mayfly *Hexagenia* sp.	80	60	60	30	90	70
Midge *Chironomus tentans*	50	60	100	100	90	90
Snail *Physa gyrina*	90	90	90	100	90	80
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	90	100	80	90	100	100

Table 24. Survival of selected aquatic organisms exposed to sediment from St. Paul Barge Terminal for 4-days in hard water at 17°C in a solid phase laboratory test.

Organism	Percent survival among two groups of 10 organisms each					
	Control (aerated)		Control (unaerated)		Exposed	
	A	B	A	B	A	B
Scud *Gammarus pseudolimnaeus*	100	80	70	80	100	90
Crayfish *Procambarus* sp.	90	80	---	---	70	100
Mayfly *Hexagenia* sp.	90	100	100	70	100	70
Midge *Chironomus tentans*	60	60	100	100	90	90
Snail *Physa gyrina*	70	80	60	90	90	80
Fawnsfoot clam *Truncilla donaciformis*	100	100	---	---	100	100
Fingernail clam *Sphaerium* sp.	90	100	100	100	100	90

Table 25. Hydrometer particle size analysis of a sediment sample[a] from Read's Landing.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0005	0.99	48.11
	1.0007	1.32	48.11
	(1.0006)	(1.16)	(48.11)
5	1.0008	1.32	30.43
	1.0009	1.49	30.43
	(1.0009)	(1.41)	(30.43)
15	1.0002	0.33	17.73
	1.0013	2.15	17.57
	(1.0008)	(1.24)	(17.65)
30	1.0005	0.83	12.42
	1.0009	1.49	12.42
	(1.0007)	(1.16)	(12.42)
60	1.0003	0.50	8.87
	1.0008	1.32	8.78
	(1.0006)	(0.91)	(8.83)
250	1.0008	1.32	4.30
	1.0011	1.65	4.30
	(1.0010)	(1.49)	(4.30)
1,440	1.0009	1.49	1.79
	1.0011	1.82	1.79
	(1.0010)	(1.66)	(1.79)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 26. Hydrometer particle size analysis of a sediment sample[a] fr n St. Paul Barge Terminal.

Time (min)	yrodmeter reading	Percent	Diameter (microns)
2	1.0126	31.69	34.63
	1.0115	28.92	34.89
	(1.0121)	(30.31)	(34.76)
5	1.0100	25.15	22.57
	1.0101	25.40	22.57
	(1.0101)	(25.28)	(22.57)
15	1.0084	21.12	13.27
	1.0085	21.38	13.13
	(1.0085)	(21.25)	(13.20)
30	1.0076	19.11	9.38
	1.0075	18.86	9.38
	(1.0076)	(18.99)	(9.38)
60	1.0071	17.86	6.68
	1.0073	18.36	6.68
	(1.0072)	(18.11)	(6.68)
250	1.0064	16.09	3.31
	1.0067	16.85	3.27
	(1.0066)	(16.47)	(3.29)
1,440	1.0049	12.32	1.39
	1.0048	12.32	1.39
	(1.0049)	(12.32)	(1.39)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 27. Hydrometer particle size analysis of a sediment sample[a] from Truedale Slough.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0009	1.49	48.86
	1.0005	0.83	48.86
	(1.0007)	(1.16)	(48.86)
5	1.0007	1.16	30.90
	1.0003	0.50	31.19
	(1.0005)	(0.83)	(31.05)
15	1.0009	1.49	17.84
	1.0010	1.66	17.84
	(1.0010)	(1.58)	(17.84)
30	1.0009	1.49	12.61
	1.0010	1.66	12.61
	(1.0010)	(1.58)	(12.61)
60	1.0009	1.49	8.92
	1.0010	1.66	8.92
	(1.0010)	(1.58)	(8.92)
250	1.0006	0.99	4.37
	1.0009	1.49	4.37
	(1.0008)	(1.24)	(4.37)
1,440	1.0011	1.82	1.82
	1.0010	1.66	1.82
	(1.0011)	(1.74)	(1.82)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 28. Hydrometer particle size analysis of a sediment sample[a] from Red Wing Commercial Harbor.

Time (min)	Hydrometer reading	Percent	Diameter (microns)
2	1.0260	86.51	29.56
	1.0260	86.51	29.56
	(1.0260)	(86.51)	(29.56)
5	1.0220	73.20	19.76
	1.0235	78.19	19.28
	(1.0228)	(75.70)	(19.52)
15	1.0195	64.88	11.68
	1.0202	67.21	11.68
	(1.0199)	(66.05)	(11.68)
30	1.0175	58.23	8.44
	1.0180	59.89	8.44
	(1.0178)	(59.06)	(8.44)
60	1.0155	51.57	6.12
	1.0160	53.24	6.12
	(1.0158)	(52.41)	(6.12)
250	1.0120	39.93	3.12
	1.0125	41.59	3.10
	(1.0123)	(40.76)	(3.11)
1,440	1.0086	28.61	1.34
	1.0090	29.94	1.34
	(1.0088)	(29.28)	(1.34)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 29. Hydrometer particle size analysis of a sediment sample[a] from West Newton.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0002	0.31	49.75
	1.0001	0.15	49.75
	(1.0002)	(0.23)	(49.75)
5	1.0001	0.15	31.47
	1.0001	0.15	31.47
	(1.0001)	(0.15)	(31.47)
15	1.0001	0.15	18.17
	1.0002	0.31	18.17
	(1.0002)	(0.23)	(18.17)
30	1.0004	0.61	12.85
	1.0003	0.46	12.85
	(1.0004)	(0.54)	(12.85)
60	1.0002	0.31	9.08
	1.0002	0.31	9.08
	(1.0002)	(0.31)	(9.08)
250	1.0003	0.45	4.45
	1.0001	0.15	4.45
	(1.0002)	(0.30)	(4.45)
1,440	1.0006	0.92	1.84
	1.0003	0.46	1.85
	(1.0005)	(0.69)	(1.85)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 30. Hydrometer particle size analysis of a sediment sample[a] from Somerfield Island.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0003	0.50	48.91
	1.0005	0.83	48.46
	(1.0004)	(0.67)	(48.69)
5	1.0002	0.33	30.93
	1.0003	0.50	30.93
	(1.0003)	(0.42)	(30.93)
15	1.0004	0.67	17.86
	1.0004	0.67	17.86
	(1.0004)	(0.67)	(17.86)
30	1.0001	0.17	12.63
	1.0003	0.50	12.63
	(1.0002)	(0.34)	(12.63)
60	1.0001	0.17	8.93
	1.0001	0.17	8.93
	(1.0001)	(0.17)	(8.93)
250	1.0001	0.17	4.37
	1.0002	0.33	4.37
	(1.0001)	(0.25)	(4.37)
1,440	1.0002	0.33	1.82
	1.0002	0.33	1.82
	(1.0002)	(0.33)	(1.82)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 31. Hydrometer particle size analysis of a sediment sample[a] from Island 58.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0002	0.35	50.15
	1.0001	0.17	50.15
	(1.0002)	(0.26)	(50.15)
5	1.0001	0.17	31.72
	1.0001	0.17	31.72
	(1.0001)	(0.17)	(31.72)
15	1.0001	0.17	18.31
	1.0003	0.52	18.31
	(1.0002)	(0.35)	(18.31)
30	1.0007	1.22	12.83
	1.0006	1.05	12.83
	(1.0007)	(1.14)	(12.83)
60	1.0007	1.22	9.07
	1.0009	1.57	9.07
	(1.0008)	(1.40)	(9.07)
250	1.0007	1.22	4.44
	1.0005	0.87	4.44
	(1.0006)	(1.05)	(4.44)
1,440	1.0006	1.05	1.85
	1.0005	0.87	1.85
	(1.0006)	(0.96)	(1.85)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 32. Hydrometer particle size analysis of a sediment sample[a] from Winona Small Boat Harbor.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0057	22.93	60.06
	1.0052	20.92	60.67
	(1.0055)	(21.93)	(60.37)
5	1.0049	19.71	38.37
	1.0048	19.31	38.37
	(1.0049)	(19.51)	(38.37)
15	1.0041	16.49	22.30
	1.0039	15.69	22.30
	(1.0040)	(16.09)	(22.30)
30	1.0037	14.88	15.77
	1.0036	14.48	15.77
	(1.0037)	(14.68)	(15.77)
60	1.0034	13.68	11.26
	1.0030	12.07	11.26
	(1.0032)	(12.88)	(11.26)
250	1.0028	11.26	5.52
	1.0023	9.25	5.57
	(1.0026)	(10.26)	(5.55)
1,440	1.0016	6.44	2.32
	1.0015	6.03	2.32
	(1.0016)	(6.24)	(2.32)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 33. Hydrometer particle size analysis of a sediment sample[a] from Grey Cloud Slough.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0013	2.20	48.21
	1.0018	3.05	47.90
	(1.0016)	(2.53)	(48.06)
5	1.0013	2.20	30.49
	1.0016	2.71	30.30
	(1.0015)	(2.36)	(30.40)
15	1.0017	2.88	17.49
	1.0016	2.71	17.49
	(1.0017)	(2.80)	(17.49)
30	1.0019	3.22	12.37
	1.0017	2.88	12.37
	(1.0018)	(3.05)	(12.37)
60	1.0011	1.97	8.80
	1.0014	2.37	8.80
	(1.0013)	(2.17)	(8.80)
250	1.0013	2.20	4.31
	1.0014	2.37	4.31
	(1.0014)	(2.17)	(4.31)
1,440	1.0013	2.20	1.80
	1.0012	2.04	1.80
	(1.0013)	(2.12)	(1.80)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 34. Hydrometer particle size analysis of a sediment sample[a] from below Cudahy.

Time (min)	Hyrodmeter reading	Percent	Diameter (microns)
2	1.0056	10.30	49.97
	1.0058	10.67	49.97
	(1.0057)	(10.49)	(49.97)
5	1.0049	9.01	31.92
	1.0051	9.38	31.92
	(1.0050)	(9.20)	(31.92)
15	1.0043	7.91	18.55
	1.0045	8.27	18.43
	(1.0044)	(8.09)	(18.49)
30	1.0043	7.91	13.12
	1.0041	7.54	13.12
	(1.0042)	(7.73)	(13.12)
60	1.0037	6.80	9.28
	1.0034	6.25	9.37
	(1.0036)	(6.53)	(9.32)
250	1.0032	5.88	4.59
	1.0030	5.52	4.59
	(1.0031)	(5.70)	(4.59)
1,440	1.0022	4.05	1.93
	1.0024	4.41	1.93
	(1.0023)	(4.23)	(1.93)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 35. Sieve particle size analysis of a sediment sample[a] from Read's Landing.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	2.68	114.8	97.7
		2.68	114.[illegible]	97.7
		(2.68)	(114.8)	(97.7)
18	1,000	10.0	104.8	89.2
		13.0	101.8	86.6
		(11.5)	(103.3)	(87.9)
35	500	58.5	46.3	39.4
		67.3	34.5	29.4
		(62.9)	(40.4)	(34.4)
60	250	38.7	7.62	6.49
		31.9	2.62	2.23
		(35.3)	(5.12)	(4.36)
120	125	5.7	1.92	1.63
		1.9	0.72	0.61
		(3.8)	(1.32)	(1.12)
200	74	0.9	1.02	0.87
		0.2	0.52	0.44
		(0.6)	(0.77)	(0.66)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 36. Sieve particle size analysis of a sediment sample[a] from St. Paul Barge Terminal.

Sieve number	Pore size (μm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0.0	63.9	100
		0.0	63.9	100
		(0.0)	(63.9)	(100)
18	1,000	0.0	63.9	100
		0.0	63.9	100
		(0.0)	(63.9)	(100)
35	500	0.2	63.7	99.7
		0.3	63.6	99.5
		(0.3)	(63.7)	(99.6)
60	250	0.5	63.2	98.9
		0.6	63.0	98.6
		(0.6)	(63.1)	(98.8)
120	125	12.6	50.6	79.2
		13.0	50.0	78.2
		(12.8)	(50.3)	(78.7)
200	74	25.4	25.2	39.4
		25.1	24.9	39.0
		(25.3)	(25.1)	(39.2)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 37. Sieve particle size analysis of a sediment sample[a] from Truedale Slough.

Sieve number	Pore size (μm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	4.42 4.42 (4.42)	114.74 114.74 (114.74)	96.29 96.29 (96.29)
18	1,000	14.4 12.4 (13.4)	100.34 102.34 (101.34)	84.21 85.88 (85.05)
35	500	36.4 31.5 (34.0)	63.94 70.84 (67.39)	53.66 59.45 (56.56)
60	250	59.9 66.1 (63.0)	4.04 4.74 (4.39)	3.39 3.98 (3.69)
120	125	3.00 3.70 (3.35)	1.04 1.04 (1.04)	0.87 0.87 (0.87)
200	74	0.10 0.20 (0.15)	0.94 0.84 (0.89)	0.79 0.70 (0.75)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 38. Sieve particle size analysis of a sediment sample[a] from Red Wing Commercial Harbor.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0	47.67	100
		0	47.67	100
		(0)	(47.67)	(100)
18	1,000	0	47.67	100
		0	47.67	100
		(0)	(47.67)	(100)
35	500	0.10	47.57	99.79
		0.10	47.57	99.79
		(0.10)	(47.57)	(99.79)
60	250	0.20	47.37	99.37
		0.20	47.37	99.37
		(0.20)	(47.37)	(99.37)
120	125	1.20	46.17	96.85
		1.20	46.17	96.85
		(1.20)	(46.17)	(96.85)
200	74	0.90	45.27	94.97
		0.90	45.27	94.97
		(0.90)	(45.27)	(94.97)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 39. Sieve particle size analysis of a sediment sample[a] from West Newton.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	15.0 15.0 (15.0)	115.2 114.9 (115.1)	88.7 88.5 (88.6)
18	1,000	21.6 10.0 (15.8)	93.6 104.9 (99.3)	72.1 80.8 (84.8)
35	500	55.9 47.2 (51.6)	37.7 57.7 (47.7)	29.0 44.4 (36.7)
60	250	37.2 54.8 (46.0)	0.50 2.90 (1.70)	0.39 2.23 (1.31)
120	125	0.40 2.70 (1.55)	0.10 0.20 (0.15)	0.08 0.15 (0.12)
200	74	0.10 0.20 (0.15)	0.0 0.0 (0.0)	0.0 0.0 (0.0)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 40. Sieve particle size analysis of a sediment sample[a] from Somerfield Island.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	2.51	124.9	98.0
		2.51	124.9	98.0
		(2.51)	(124.9)	(98.0)
18	1,000	8.00	116.9	91.7
		5.80	119.1	93.5
		(6.90)	(118.0)	(92.6)
35	500	28.7	88.2	69.2
		22.6	96.5	75.7
		(25.7)	(92.4)	(72.5)
60	250	69.0	19.2	15.1
		61.9	34.6	27.2
		(65.5)	(26.9)	(21.2)
120	125	18.3	0.91	0.71
		23.4	11.21	8.80
		(20.9)	(6.06)	(4.76)
200	74	0.60	0.31	0.24
		0.80	10.41	8.17
		(0.70)	(5.36)	(4.21)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 41. Sieve particle size analysis of a sediment sample[a] from Island 58.

Sieve number	Pore size (μm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0.0	114.9	(100)
		0.0	114.9	(100)
		(0.0)	(114.9)	(100)
18	1,000	19.1	95.8	83.4
		12.3	102.6	89.4
		(15.7)	(99.2)	(86.4)
35	500	53.5	42.3	36.8
		48.1	54.5	47.4
		(50.8)	(48.4)	(42.1)
60	250	41.3	1.01	0.88
		52.6	1.90	1.65
		(47.0)	(1.46)	(1.27)
120	125	0.50	0.51	0.44
		1.30	0.60	0.52
		(0.90)	(0.56)	(0.48)
200	74	0.10	0.41	0.36
		0.0	0.60	0.52
		(0.05)	(0.51)	(0.44)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 42. Sieve particle size analysis of a sediment sample[a] from Winona Small Boat Harbor.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0.0 0.0 (0.0)	64.6 64.6 (64.6)	100 100 (100)
18	1,000	0.50 0.70 (0.60)	64.1 63.9 (64.0)	99.2 98.9 (99.1)
35	500	3.80 3.80 (3.80)	60.3 60.1 (60.2)	93.3 93.0 (93.2)
60	250	11.9 12.4 (12.2)	48.4 47.7 (48.1)	74.9 73.8 (74.4)
120	125	19.8 19.8 (19.8)	28.6 27.9 (28.3)	44.3 43.2 (43.8)
200	74	3.3 2.9 (3.1)	25.3 25.0 (25.2)	39.2 38.7 (39.0)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 43. Sieve particle size analysis of a sediment sample[a] from Grey Cloud Slough.

Sieve number	Pore size (μm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0.0 0.0 (0.0)	114.8 114.8 (114.8)	100 100 (100)
18	1,000	21.4 15.9 (18.7)	93.4 98.9 (96.2)	81.4 86.1 (83.8)
35	500	49.6 49.2 (49.4)	43.8 49.7 (46.8)	38.2 43.3 (40.8)
60	250	39.5 44.9 (42.1)	4.3 4.8 (4.6)	3.75 4.18 (3.97)
120	125	1.3 1.6 (1.5)	3.0 3.2 (3.1)	2.61 2.79 (2.70)
200	74	0.0 0.0 (0.0)	3.0 3.2 (3.1)	2.61 2.79 (2.70)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 44. Sieve particle size analysis of a sediment sample[a] from below Cudahy.

Sieve number	Pore size (µm)	Mass retained (g)	Mass passing (g)	Amount passing (%)
10	2,000	0.0 0.0 (0.0)	114.6 114.6 (114.6)	100 100 (100)
18	1,000	17.2 24.6 (20.9)	97.4 90.0 (93.7)	85.0 78.5 (81.8)
35	500	47.6 46.2 (46.9)	49.8 43.8 (46.8)	43.5 38.2 (40.9)
60	250	29.8 32.1 (31.0)	20.0 11.7 (15.9)	17.5 10.2 (13.9)
120	125	4.2 4.8 (4.5)	15.8 6.9 (11.4)	13.8 6.0 (9.9)
200	74	2.7 3.1 (2.9)	13.1 3.8 (8.5)	11.4 3.3 (7.4)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 45. Particle size characterization of a sediment sample[a] from Read's Landing.

Soil type	Particle size (µm)	Amount (%)
Sand		
Coarse	2,000-4,750	2 2 (2)
Medium	425-2,000	69 77 (73)
Fine	74-425	28 21 (25)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	1 1 (1)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 46. Particle size characterization of a sediment sample[a] from St. Paul Barge Terminal.

Soil type	Particle size (µm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	1 1 (1)
Fine	74-425	60 60 (60)
Silt	5-74	24 22 (23)
Clay	1-5	8 9 (9)
Colloid	< 1	10 9 (10)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 47. Particle size characterization of a sediment sample[a] from Truedale Slough.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	4 4 (4)
Medium	425-2,000	56 51 (54)
Fine	74-425	39 44 (42)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	1 1 (1)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 48. Particle size characterization of a sediment sample[a] from Red Wing Commercial Harbor.

Soil type	Particle size (µm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	0 0 (0)
Fine	74-425	5 5 (5)
Silt	5-74	47 45 (46)
Clay	1-5	31 32 (32)
Colloid	<1	17 18 (18)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 49. Particle size characterization of a sediment sample[a] from West Newton.

Soil type	Particle size (µm)	Amount (%)
Sand		
Coarse	2,000-4,750	11 12 (12)
Medium	425-2,000	68 56 (62)
Fine	74-425	21 32 (27)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	0 0 (0)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 50. Particle size characterization of a sediment sample[a] from Somerfield Island.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	2 2 (2)
Medium	425-2,000	38 31 (35)
Fine	74-425	60 67 (64)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	0 0 (0)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 51. Particle size characterization of a sediment sample[a] from Island 58.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	73 67 (70)
Fine	74-425	27 33 (30)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	1 1 (1)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 52. Particle size characterization of a sediment sample[a] from Winona Small Boat Harbor.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	10 11 (11)
Fine	74-425	51 50 (51)
Silt	5-74	23 25 (24)
Clay	1-5	12 9 (11)
Colloid	< 1	3 3 (3)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 53. Particle size characterization of a sediment sample[a] from Grey Cloud Slough.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	72 69 (71)
Fine	74-425	25 28 (27)
Silt	5-74	0 0 (0)
Clay	1-5	0 0 (0)
Colloid	< 1	2 2 (2)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 54. Particle size characterization of a sediment sample[a] from Below Cudahy.

Soil type	Particle size (μm)	Amount (%)
Sand		
Coarse	2,000-4,750	0 0 (0)
Medium	425-2,000	65 71 (68)
Fine	74-425	24 26 (25)
Silt	5-74	5 5 (5)
Clay	1-5	4 4 (4)
Colloid	< 1	2 2 (2)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 55. Quantitative characterization of reconstituted water which was used for preparation of particulate and elutiate phases.

Characteristic	Units	Concentration
Volatile solids[a]	%	<0.10 <0.10 (<0.10)
pH		8.29 8.23 (8.26)
COD	mg/L	<10 <10 (<10)
BOD	mg/L	<0.10 <0.10 (<0.10)
Total phosphate	mg/L	<0.10 <0.10 (<0.10)
Ortho phosphate	mg/L	<0.10 <0.10 (<0.10)
Ammonia N	mg/L	<0.05 <0.05 (<0.05)
Nitrite N	mg/L	<0.002 <0.002 (<0.002)
Nitrate N	mg/L	<0.02 <0.02 (<0.02)
Oil and Grease	mg/L	<5.0 <5.0 (<5.0)
Chromium	mg/L	<0.005 <0.005 (<0.005)

(more)

Table 55. (cont'd)

Characteristic	Units	Concentration
Copper	mg/L	<0.005 <0.005 (<0.005)
Lead	mg/L	<0.005 <0.005 (<0.005)
Zinc	mg/L	<0.001 <0.001 (<0.001)
Iron	mg/L	<0.010 <0.010 (<0.010)
Nickel	mg/L	<0.010 <0.010 (<0.010)
Mercury	mg/L	<0.001 <0.001 (<0.001)
Cadmium	µg/L	<0.50 <0.50 (<0.50)
PCB as Aroclor 1254	µg/L	<0.20 <0.20 (<0.20)
DDD	µg/L	<0.05 <0.05 (<0.05)
DDE	µg/L	<0.05 <0.05 (<0.05)
DDT	µg/L	<0.10 <0.10 (<0.10)

(more)

Table 55. (cont'd)

Characteristic	Units	Concentration
Endrin	µg/L	<0.05
		<0.05
		(<0.05)
Dieldrin	µg/L	<0.05
		<0.05
		(<0.05)
Chlordane	µg/L	<0.10
		<0.10
		(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parentheses.

Table 56. Quantitative characterization of three phases of a sediment sample[a] from Read's Landing.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.35 0.24 (0.30)	6.77 10.2 (8.49)	17.8 47.1 (32.5)
pH	7.68 7.77 (7.23)	8.04 7.84 (7.94)	8.56 8.15 (8.36)
	μg/g	mg/L	mg/L
COD	560 493 (527)	82.5 76.0 (79.3)	108 104 (106)
BOD	39.7 56.1 (47.9)	11.0 2.3 (6.7)	5.00 19.5 (12.3)
Total phosphate	678 666 (672)	--- --- ---	0.20 0.23 (0.22)
Ortho phosphate	10.0 10.0 (10.0)	0.60 0.80 (0.70)	<0.10 <0.10 (<0.10)
Ammonia N	<0.50 <0.50 (<0.50)	<0.050 <0.050 (<0.050)	0.078 0.070 (0.074)
Nitrite N	0.030 0.030 (0.030)	0.007 0.008 (0.008)	0.007 0.007 (0.007)
Nitrate N	0.595 0.630 (0.613)	0.140 0.175 (0.158)	0.270 0.328 (0.299)
Oil and grease	200 170 (185)	21.0 32.0 (26.5)	<5.00 <5.00 <5.00
Chromium	16.0 13.0 (14.5)	0.214 0.214 (0.214)	<0.005 <0.005 (<0.005)

(more)

Table 56. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	1.62 1.62 (1.62)	0.072 0.072 (0.072)	<0.005 <0.005 (<0.005)
Lead	3.44 1.68 (2.56)	0.012 <0.005 (<0.009)	<0.005 <0.005 (<0.005)
Zinc	57.0 39.0 (48.)	<0.001 <0.001 (<0.001)	<0.001 <0.001 (<0.001)
Iron	9,320 11,320 (10,320)	96.0 186 (141)	<0.010 <0.010 (<0.010)
Nickel	12.5 13.0 (12.8)	<0.010 <0.010 (<0.010)	<0.010 <0.010 (<0.010)
Mercury	<0.010 <0.010 (<0.010)	<0.001 <0.001 (<0.001)	<0.001 <0.001 (<0.001)
	ng/g	µg/L	µg/L
Cadmium	715 794 (755)	43.3 25.7 (34.5)	18.3 1.45 (9.88)
PCB as Aroclor 1254	<1.00 <1.00 (<1.00)	---[b] --- ---	<0.20 <0.20 (<0.20)
DDD	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 <0.05 (<0.05)
DDE	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 (<0.05) (<0.05)

(more)

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BIOLOGICAL ACTIVITY AND CHEMICAL CHARACTERISTICS OF DREDGE MATE--ETC(U)
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Table 56. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
DDT	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	0.90
	<0.20	---	0.44
	(<0.20)	---	(0.67)
Chlordane	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 57. Quantitative characterization of three phases of a sediment sample[a] from St. Paul Barge Terminal.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile soldids (%)	3.96 2.76 (3.36)	14.7 12.7 (13.7)	18.0 29.5 (23.8)
pH	7.39 7.43 (7.41)	7.72 7.49 (7.61)	8.32 8.04 (8.18)
	µg/g	mg/L	mg/L
COD	21,400 15,300 (18,400)	580 376 (478)	344 351 (348)
BOD	912 1,060 (986)	41.0 13.0 (27.0)	14.0 18.0 (16.0)
Total Phosphate	1,750 1,780 (1,770)	--- --- ---	0.28 0.33 (0.31)
Ortho Phosphate	48.8 47.5 (48.2)	0.30 0.40 (0.35)	<0.10 <0.10 (<0.10)
Ammonia N	30.0 30.0 (30.0)	8.20 8.40 (8.30)	6.07 6.26 (6.17)
Nitrite N	0.070 0.070 (0.070)	0.020 0.021 (0.021)	0.011 0.012 (0.012)
Nitrate N	0.655 0.440 (0.548)	0.156 0.191 (0.174)	0.127 0.236 (0.182)
Oil and Grease	490 630 (560)	33.0 11.0 (22.0)	<5.00 <5.00 (<5.00)
Chromium	38.3 38.7 (38.5)	2.28 2.24 (2.26)	<0.005 0.008 (<0.007)

(more)

Table 57. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	8.80	0.76	<0.005
	8.80	0.82	<0.005
	(8.80)	(0.79)	(<0.005)
Lead	17.5	1.12	<0.005
	21.5	1.08	<0.005
	(19.5)	(1.10)	(<0.005)
Zinc	194	8.28	1.78
	210	10.6	1.08
	(202)	(9.44)	(1.43)
Iron	12,700	895	<0.010
	16,300	1,260	<0.010
	(14,500)	(1,080)	(<0.010)
Nickel	21.6	1.42	<0.010
	23.2	1.30	<0.010
	(22.4)	(1.36)	(<0.010)
Mercury	<0.010	0.002	<0.001
	<0.010	0.002	<0.001
	(<0.010)	(0.002)	(<0.001)
	ng/g	µg/L	µg/L
Cadmium	866	57.3	11.7
	632	43.6	76.9
	(749)	(50.5)	(44.3)
PCB as Aroclor 1254	17.4	---[b]	<0.20
	14.3	---	<0.20
	(15.9)	---	(<0.20)
DDD	1.48	---	<0.05
	1.37	---	<0.05
	(1.43)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDT	0.58	---	<0.10
	2.78	---	<0.10
	(1.68)	---	(<0.10)

(more)

Table 57. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	0.20	---	0.05
	0.20	---	0.05
	(0.20)	---	(0.05)
Dieldrin	0.64	---	1.08
	0.67	---	0.36
	(0.66)	---	(0.72)
Chlordane	3.29	---	<0.10
	2.90	---	<0.10
	(3.05)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 58. Quantitative characterization of three phases of a sediment sample[a] from Truedale Slough.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.17	16.8	29.1
	0.05	21.1	25.6
	(0.11)	(19.0)	(27.4)
pH	8.16	8.20	8.27
	8.16	8.26	8.14
	(8.16)	(8.23)	(8.21)
	<u>ug/g</u>	<u>mg/L</u>	<u>mg/L</u>
COD	1,090	135	46.6
	158	88.2	50.7
	(624)	(112)	(48.7)
BOD	18.8	3.20	1.80
	19.1	3.00	5.40
	(19.0)	(3.10)	(3.60)
Total Phosphate	521	---	0.25
	501	---	0.25
	(511)	---	(0.25)
Ortho Phosphate	20.0	1.10	<0.10
	22.5	---	<0.10
	(21.3)	(1.10)	(<0.10)
Ammonia N	<0.50	<0.050	<0.050
	<0.50	<0.050	<0.050
	(<0.50)	(<0.050)	(<0.050)
Nitrite N	<0.010	<0.002	<0.002
	<0.010	<0.002	<0.002
	(<0.010)	(<0.002)	(<0.002)
Nitrate N	1.25	0.44	0.49
	1.35	0.33	0.43
	(1.30)	(0.39)	(0.46)
Oil and Grease	380	8.0	0.40
	960	7.1	1.20
	(670)	(7.6)	(0.80)
Chromium	25.6	0.24	0.008
	28.0	0.18	<0.005
	(26.8)	(0.21)	(<0.007)

(more)

Table 58. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	2.12	0.012	<0.005
	2.20	0.008	<0.005
	(2.16)	(0.010)	(<0.005)
Lead	2.64	<0.005	<0.005
	4.16	<0.005	<0.005
	(3.40)	(<0.005)	(<0.005)
Zinc	4.40	0.92	0.57
	24.4	1.08	0.47
	(14.4)	(1.00)	(0.52)
Iron	8,184	84.2	<0.010
	7,534	46.7	<0.010
	(7,859)	(65.5)	(<0.010)
Nickel	13.3	1.38	0.018
	15.3	0.086	<0.010
	(14.3)	(0.73)	(<0.014)
Mercury	<0.010	<0.001	<0.001
	<0.010	<0.001	<0.001
	(<0.010)	(<0.001)	(<0.001)
	ng/g	µg/L	µg/L
Cadmium	1,240	44.2	28.2
	780	73.2	19.8
	(1,010)	58.7)	(24.0)
PCB as Aroclor 1254	1.26	---[b]	<0.20
	<1.00	---	<0.20
	(<1.13)	---	(<0.20)
DDD	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	<0.20	---	<0.05
DDT	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

(more)

Table 58. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	0.91
	<0.20	---	0.46
	(<0.20)	---	(0.69)
Chlordane	<0.40	---	(<0.10)
	<0.40	---	(<0.10)
	(0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 59. Quantitative characterization of three phases of a sediment sample[a] from Red Wing Commercial Harbor.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	8.18	13.1	18.6
	7.83	12.8	19.9
	(8.01)	(13.0)	(19.3)
pH	7.45	7.32	8.06
	7.45	7.50	7.89
	(7.45)	(7.41)	(7.98)
	ug/g	mg/L	mg/L
COD	32,800	3,160	121
	37,500	3,190	111
	(35,200)	(3,180)	(116)
BOD	902	90.4	16.5
	961	96.0	2.45
	(932)	(93.2)	(3.83)
Total Phosphate	3,170	---	0.41
	3,100	---	0.43
	(3,140)	---	(0.42)
Ortho Phosphate	57.5	1.60	<0.10
	55.0	1.50	<0.10
	(56.3)	(1.55)	(<0.10)
Ammonia N	710	12.2	7.52
	686	13.5	7.10
	(698)	(12.9)	(7.31)
Nitrite N	0.080	0.042	0.020
	0.080	0.041	0.020
	(0.080)	(0.042)	(0.020)
Nitrate N	0.33	0.080	0.11
	0.42	0.11	0.084
	(0.38)	(0.095)	(0.097)
Oil and Grease	850	20.0	2.00
	210	19.0	2.80
	(530)	(19.5)	(2.40)
Chromium	88.7	1.59	<0.005
	30.7	1.65	<0.005
	(84.7)	(1.62)	(<0.005)

(more)

Table 59. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	18.2	0.91	<0.005
	17.4	0.81	<0.005
	(17.8)	(0.86)	(<0.005)
Lead	7.68	0.40	<0.005
	8.48	0.36	<0.005
	(8.08)	(0.38)	(<0.005)
Zinc	242	7.90	<0.001
	190	8.30	<0.001
	(216)	(8.10)	(<0.001)
Iron	24,300	997	<0.010
	21,500	1,100	<0.010
	(22,900)	(1,050)	(<0.010)
Nickel	53.0	1.81	<0.010
	61.8	1.71	<0.010
	(57.4)	(1.76)	(<0.010)
Mercury	0.040	0.005	<0.001
	0.030	0.003	<0.001
	(0.035)	(0.004)	(<0.001)
	ng/g	μg/L	μg/L
Cadmium	4,410	204	12.5
	4,040	193	15.6
	(4,230)	(199)	(14.1)
PCB as Aroclor 1254	52.5	---[b]	<0.20
	67.0	---	<0.20
	(59.8)	---	(<0.20)
DDD	7.25	---	<0.05
	3.30	---	<0.05
	(5.28)	---	(<0.05)
DDE	0.24	---	<0.05
	0.32	---	<0.05
	(0.28)	---	(0.05)
DDT	0.53	---	<0.10
	0.58	---	<0.10
	(0.56)	---	(0.10)

(more)

Table 59. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	0.21	---	<0.05
	0.26	---	<0.05
	(0.24)	---	(<0.05)
Dieldrin	0.92	---	0.72
	0.92	---	0.20
	(0.92)	---	(0.46)
Chlordane	7.06	---	<0.10
	7.14	---	<0.10
	(7.10)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 60. Quantitative characterization of three phases of a sediment sample[a] from West Newton.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.44	8.96	19.3
	0.56	10.3	16.1
	(0.50)	(9.63)	(17.7)
pH	7.95	8.19	8.33
	7.84	8.19	8.33
	(7.90)	(8.19)	(8.33)
	ug/g	mg/L	mg/L
COD	381	65.1	98.1
	1,840	74.6	101
	(1,110)	(69.9)	(99.6)
BOD	43.4	32.0	23.2
	41.8	34.8	24.2
	(42.6)	(33.4)	(23.7)
Total Phosphate	597	---	0.13
	581	---	0.14
	(589)	---	(0.14)
Ortho Phosphate	15.0	0.85	0.14
	15.5	0.72	0.13
	(15.3)	(0.79)	(0.14)
Ammonia N	<0.50	<0.05	<0.05
	<0.50	<0.05	<0.05
	(<0.50)	<0.05	<0.05
Nitrite N	<0.010	<0.002	<0.002
	0.010	<0.002	<0.002
	(<0.010)	<0.002	(<0.002)
Nitrate N	0.70	0.147	0.21
	0.64	0.140	0.21
	(0.67)	(0.144)	(0.21)
Oil and Grease	2,510	214	42.6
	1,740	212	171
	(2,130)	(213)	(107)
Chromium	20.1	0.30	<0.005
	36.5	0.12	<0.005
	(28.3)	(0.21)	(<0.005)

(more)

Table 60. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	6.64 8.24 (7.44)	<0.005 0.008 (<0.007)	<0.005 <0.005 (<0.005)
Lead	3.76 3.88 (3.82)	<0.005 0.022 (<0.014)	<0.005 <0.005 (<0.005)
Zinc	28.8 45.8 (37.3)	<0.001 <0.001 (<0.001)	<0.001 <0.001 (<0.001)
Iron	5,760 12,100 (8,930)	27.8 87.8 (57.8)	<0.010 <0.010 (<0.010)
Nickel	22.9 24.5 (23.7)	0.094 0.096 (0.095)	0.30 0.022 (0.16)
Mercury	<0.010 <0.010 (<0.010)	<0.001 <0.001 (<0.001)	<0.001 <0.001 (<0.001)
	ng/g	µg/L	µg/L
Cadmium	194 1430 (812)	12.5 32.2 (2[illegible].4)	52.2 43.7 (48.0)
PCB as Aroclor 1254	<1.00 <1.00 (1.00)	---[b] --- ---	<0.20 <0.20 (<0.20)
DDD	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 <0.05 (<0.05)
DDE	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 <0.05 (<0.05)
DDT	<0.40 <0.40 (<0.40)	--- --- ---	<0.10 <0.10 (<0.10)

(more)

Table 60. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Chlordane	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 61. Quantitative characterization of three phases of a sediment sample[a] from Somerfield Island.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.38 0.32 (0.35)	14.7 14.8 (14.8)	10.9 14.6 (12.8)
pH	8.18 8.12 (8.15)	8.02 7.95 (7.99)	8.19 8.17 (8.18)
	ug/g	mg/L	mg/L
COD	1,240 1,090 (1,170)	192 171 (182)	157 151 (154)
BOD	48.0 48.4 (48.2)	29.1 34.0 (31.6)	19.7 22.0 (20.9)
Total phosphate	697 671 (684)	--- --- ---	0.13 0.14 (0.14)
Ortho phosphate	18.5 20.0 (19.3)	0.75 0.80 (0.78)	<0.10 <0.10 (<0.10)
Ammonia N	<0.50 <0.50 (<0.50)	0.079 0.091 (0.085)	0.10 0.10 (0.10)
Nitrite N	<0.01 <0.01 (<0.01)	0.004 0.004 (0.004)	0.009 0.009 (0.009)
Nitrate N	0.37 0.14 (0.26)	0.077 0.079 (0.078)	0.10 0.088 (0.094)
Oil and grease	153 207 (180)	99.0 54.0 (76.5)	53.8 23.6 (38.7)
Chromium	28.2 27.8 (28.0)	0.21 0.13 (0.17)	<0.005 <0.005 (<0.005)

(more)

Table 61. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	4.08	<0.005	<0.005
	4.88	<0.005	<0.005
	(4.48)	(<0.005)	(<0.005)
Lead	0.12	<0.005	<0.005
	0.12	<0.005	<0.005
	(0.12)	(<0.005)	(<0.005)
Zinc	80.4	0.97	1.08
	70.4	2.52	1.24
	(75.4)	(1.75)	(1.16)
Iron	12,800	48.0	<0.010
	15,400	218	<0.010
	(14,100)	(133)	(<0.010)
Nickel	20.6	0.17	<0.010
	24.6	0.050	<0.010
	(22.6)	(0.11)	<0.010)
Mercury	<0.010	<0.001	<0.001
	<0.010	<0.001	<0.001
	(<0.010)	(<0.001)	(<0.001)
	ng/g	µg/L	µg/L
Cadmium	1,370	5.14	15.2
	1,480	81.1	5.34
	(1,430)	(43.1)	(10.3)
PCB as Aroclor 1254	<1.00	---[b]	<0.20
	<1.00	---	<0.20
	(<1.00)	---	(<0.20)
DDD	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDT	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

(more)

Table 61. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Chlordane	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 62. Quantitative characterization of three phases of a sediment sample[a] from Island 58.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.66	20.3	22.9
	0.54	20.1	21.1
	(0.60)	(20.2)	(22.0)
pH	7.61	7.51	7.75
	7.71	7.51	7.60
	(7.66)	(7.51	(7.68)
	ug/g	mg/L	mg/L
COD	858	94.5	121
	802	102	123
	(830)	(98.3)	(122)
BOD	60.5	35.0	16.9
	59.6	34.4	25.4
	(60.1)	(34.7)	(21.2)
Total phosphate	661	---	0.24
	691	---	0.21
	(676)	---	(0.23
Ortho phosphate	18.8	0.27	0.35
	18.8	0.20	0.30
	(18.8,	(0.24)	(0.33)
Ammonia N	<0.50	0.082	0.065
	<0.50	0.084	0.059
	(<0.50)	(0.083)	(0.062)
Nitrite N	0.014	0.002	0.004
	0.014	0.002	0.004
	(0.014)	(0.002)	(0.004)
Nitrate N	0.55	0.16	0.19
	0.49	0.16	0.21
	(0.52)	(0.16)	(0.20)
Oil and grease	2,190	347	7.70
	1,480	379	8.50
	(1,840)	(363)	(8.10)
Chromium	24.7	0.11	<0.005
	32.7	0.054	<0.005
	(28.7)	(0.082)	(<0.005)

(more)

Table 62. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	5.08 7.08 (6.08)	<0.005 <0.005 (<0.005)	<0.005 <0.005 (<0.005)
Lead	1.66 4.52 (3.09)	<0.005 <0.005 (<0.005)	<0.005 <0.005 (<0.005)
Zinc	59.6 95.6 (77.6)	1.60 0.98 (1.29)	0.76 0.22 (0.49)
Iron	9,560 12,400 (11,000)	34.0 106 (70.0)	<0.010 <0.010 (<0.010)
Nickel	20.9 24.5 (22.7)	0.076 0.28 (0.18)	<0.010 <0.010 (<0.010)
Mercury	<0.010 <0.010 (<0.010)	<0.001 <0.001 (<0.001)	<0.001 <0.001 (<0.001)
	ng/g	µg/L	µg/L
Cadmium	827 1,070 (949)	31.2 14.6 (22.9)	<0.50 2.58 (<1.54)
PCB as Aroclor 1254	<1.00 <1.00 (<1.00)	---[b] --- ---	<0.20 <0.20 (<0.20)
DDD	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 <0.05 (<0.05)
DDE	<0.20 <0.20 (<0.20)	--- --- ---	<0.05 <0.05 (<0.05)
DDT	<0.40 <0.40 (<0.40)	--- --- ---	<0.10 <0.10 (<0.10)

(more)

Table 62. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Chlordane	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed, mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 63. Quantitative characterization of three phases of a sediment sample[a] from Winona Small Boat Harbor.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	2.17 2.07 (2.12)	12.4 12.8 (12.6)	24.8 29.7 (27.3)
pH	7.45 7.46 (7.46)	7.35 7.36 (7.36)	7.66 7.61 (7.64)
	µg/g	mg/L	mg/L
COD	13,800 14,100 (14,000)	197 315 (256)	128 129 (129)
BOD	714 670 (692)	29.7 34.4 (32.1)	27.8 25.5 (26.7)
Total Phosphate	985 1,150 (1,070)	--- --- ---	0.17 0.18 (0.18)
Ortho Phosphate	22.5 22.5 (22.5)	0.65 0.65 (0.65)	0.16 0.16 (0.16)
Ammonia N	8.40 9.00 (8.70)	1.80 1.87 (1.84)	1.50 1.58 (1.54)
Nitrite N	0.033 0.033 (0.033)	0.020 0.020 (0.020)	0.023 0.024 (0.024)
Nitrate N	0.13 0.33 (0.23)	0.14 0.16 (0.15)	0.23 0.24 (0.24)
Oil and Grease	---[b] --- ---	---[b] --- ---	21.8 47.2 (34.5)
Chromium	34.2 35.8 (35.0)	0.87 0.87 (0.87)	<0.005 0.012 (<0.009)

(more)

Table 63. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	8.68	0.11	<0.005
	9.08	0.13	<0.005
	(8.88)	(0.12)	<0.005)
Lead	2.64	0.10	<0.005
	4.24	0.15	<0.005
	(3.44)	(0.13)	(<0.005)
Zinc	63.2	3.41	<0.001
	69.2	1.81	<0.001
	(66.2)	(2.61)	<0.001
Iron	10,400	288	<0.010
	11,600	218	<0.010
	(11,000)	(253)	(<0.010)
Nickel	22.2	1.59	<0.010
	23.4	6.99	0.020
	(22.8)	(4.29)	(<0.015)
Mercury	<0.010	<0.001	<0.001
	<0.010	<0.001	<0.001
	(<0.010)	(<0.001)	<0.001
	ng/g	µg/L	µg/L
Cadmium	1,670	61.3	9.28
	1,490	74.1	2.84
	(1,580)	(67.7)	(6.06)
PCB as Aroclor 1254	30.4	---[c]	<0.20
	19.4	---	<0.20
	(24.9)	---	(<0.20)
DDD	0.56	---	<0.05
	0.62	---	<0.05
	(0.59)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.02)	---	(<0.05)
DDT	<0.40	---	<0.10
	<0.40	---	0.10
	(<0.40)	---	(<0.10)

(more)

Table 63. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	0.21	---	<0.05
	0.21	---	<0.05
	(0.21)	---	(<0.05)
Chlordane	0.61	---	<0.10
	0.64	---	<0.10
	(0.63)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.
[c]Methodology not available for this sample matrix.

Table C4. Quantitative characterization of three phases of a sediment sample[a] from Grey Cloud Slough.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	0.58	15.8	24.1
	0.50	13.1	28.7
	(0.54)	(14.5)	(26.4)
pH	7.99	7.93	8.08
	7.97	7.90	8.11
	(7.98)	(7.92)	(8.10)
	ug/g	mg/L	mg/L
COD	2,690	576	231
	2,820	586	232
	(2,760)	(581)	(232)
BOD	167	37.4	12.0
	168	41.4	9.90
	(168)	(39.4)	(11.0)
Total Phosphate	868	---	0.32
	838	---	0.32
	(853)	---	(0.32)
Ortho Phosphate	40.0	2.15	0.26
	41.3	1.85	0.25
	(40.7)	(2.00)	(0.26)
Ammonia N	3.20	1.58	1.35
	3.20	1.51	1.45
	(3.20)	(1.55)	(1.40)
Nitrite N	0.040	0.073	0.077
	0.040	0.074	0.077
	(0.040)	(0.074)	(0.077)
Nitrate N	0.10	0.056	0.17
	0.18	0.075	0.15
	(0.14)	(0.066)	(0.16)
Oil and Grease	1,030	1,030	22.0
	14,700	806	22.2
	(7,870)	(918)	(22.1)
Chromium	35.6	0.88	0.010
	30.8	0.82	0.012
	(33.2)	(0.85)	(0.011)

(more)

Table 64. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	6.84	0.15	<0.005
	6.44	0.15	<0.005
	(6.64)	(0.15)	(<0.005)
Lead	4.80	0.13	<0.005
	5.00	0.13	<0.005
	(4.90)	(0.13)	(<0.005)
Zinc	66.4	5.72	1.52
	66.4	2.82	0.26
	(66.4)	(4.27)	(0.89)
Iron	11,000	166	<0.010
	11,200	158	<0.010
	(11,100)	(162)	(<0.010)
Nickel	30.5	0.38	0.036
	26.9	1.32	0.35
	(28.7)	(0.85)	(0.19)
Mercury	<0.010	<0.001	<0.001
	<0.010	<0.001	<0.001
	(<0.010)	<0.001	(<0.001)
	ng/g	µg/L	µg/L
Cadmium	1,010	59.1	1.14
	910	49.1	3.72
	(960)	(54.1)	(2.43)
PCB as Aroclor 1254	1.16	---[b]	<0.20
	1.23	---	<0.20
	(1.20)	---	(<0.20)
DDD	<0.20	---	<0.05
	<0.20	---	<0.05
	(0.20)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDT	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

(more)

Table 64. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Dieldrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Chlordane	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

Table 65. Quantitative characterization of three phases of a sediment sampled[a] from below Cudahy.

Characteristic and units	Solid	Suspended particulate	Liquid
Volatile solids (%)	1.14	14.8	22.1
	4.35	4.56	30.9
	(2.88)	(9.68)	(26.5)
pH	7.75	7.72	8.07
	7.65	7.67	8.10
	(7.70)	(7.70)	(8.09)
	ug/g	mg/L	mg/L
COD	6,450	288	199
	6,750	251	197
	(6,600)	(270)	(198)
BOD	507	32.0	17.4
	479	28.8	17.1
	(493)	(30.4)	(17.3)
Total Phosphate	1,830	---	0.24
	1,700	---	0.32
	(1,770)	---	(0.28)
Ortho Phosphate	61.3	1.35	0.20
	62.5	1.34	0.22
	(61.9)	(1.35)	(0.21)
Ammonia N	9.00	3.64	2.94
	8.50	3.30	2.80
	(8.75)	(3.47)	(2.88)
Nitrite N	0.030	0.037	0.040
	0.030	0.037	0.041
	(0.030)	(0.037)	(0.041)
Nitrate N	0.23	0.062	0.14
	0.23	0.065	0.16
	(0.23)	(0.064)	(0.15)
Oil and Grease	6,880	40.0	45.2
	17,900	152	13.7
	(12,400)	(96.0)	(29.5)
Chromium	63.1	0.67	<0.005
	49.1	0.69	0.032
	(56.1)	(0.68)	(<0.019)

(more)

Table 65. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Copper	14.6	0.15	<0.005
	4.56	0.17	<0.005
	(9.58)	(0.16)	<0.005
Lead	8.64	0.052	<0.005
	6.24	0.072	<0.005
	(7.44)	(0.062)	(<0.005)
Zinc	162	4.25	0.32
	152	4.40	0.86
	(157)	(4.33)	(0.59)
Iron	14,800	38.4	<0.010
	9,970	8.44	<0.010
	(12,400)	(23.4)	(<0.010)
Nickel	27.5	0.65	0.058
	18.3	0.49	0.34
	(22.9)	(0.57)	(0.20)
Mercury	<0.010	<0.001	<0.001
	<0.010	<0.001	<0.001
	(<0.010)	(<0.001)	(<0.001)
	ng/g	µg/L	µg/L
Cadmium	2,120	74.7	25.9
	1,690	147	41.2
	(1,910)	(111)	(33.6)
PCB as Aroclor 1254	4.82	---[b]	<0.20
	4.80	---	<0.20
	(4.81)	---	(<0.20)
DDD	0.76	---	<0.05
	0.44	---	<0.05
	(0.60)	---	(<0.05)
DDE	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
DDT	<0.40	---	<0.10
	<0.40	---	<0.10
	(<0.40)	---	(<0.10)

(more)

Table 65. (cont'd)

Characteristic and units	Solid	Suspended particulate	Liquid
Endrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(0.05)
Dieldrin	<0.20	---	<0.05
	<0.20	---	<0.05
	(<0.20)	---	(<0.05)
Chlordane	0.81	---	<0.10
	0.84	---	<0.10
	(0.83)	---	(<0.10)

[a]Duplicate subsamples were analyzed; mean is in parenteses.
[b]Methodology not available for this sample matrix.

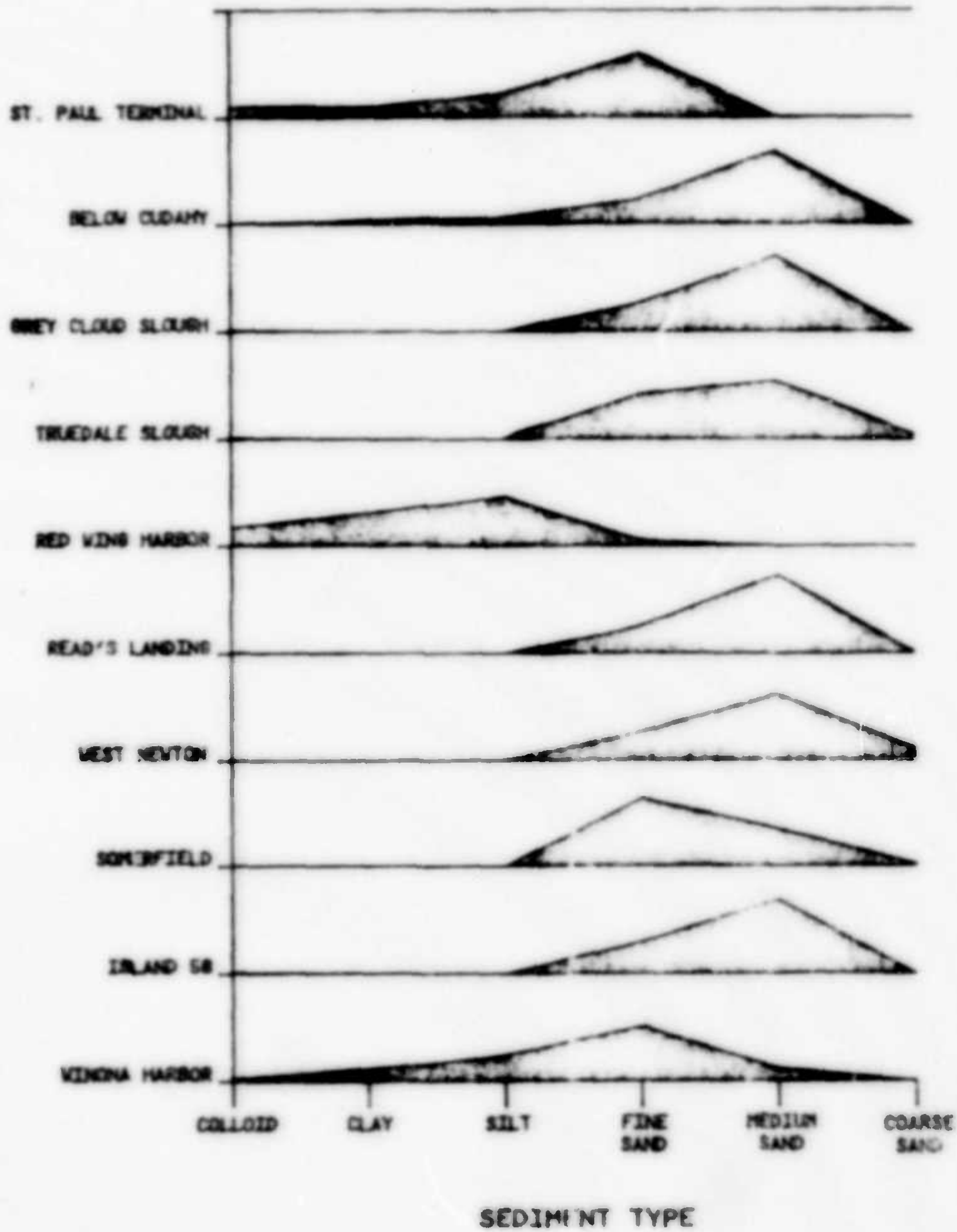

Fig. 1. Particle size distribution (Percent of total weight) of sediment samples from 10 sites on the Upper Mississippi River.

Appendix I

Summary of Chemical Characteristics of Test Solutions

Table 1. Characteristics of test media prepared from dredge spoil sediments from Read's Landing in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Aerated control					
0	7.92	9.2	---	1.1	<0.5
24	7.72	8.4	---	2.6	<0.5
48	8.42	9.1	---	3.3	<0.5
72	8.44	9.3	---	2.1	<0.5
96	8.40	9.3	---	1.8	<0.5
Unaerated control					
0	7.80	8.9	---	---	<0.5
24	7.62	5.7	---	---	<0.5
48	7.93	5.2	---	---	<0.5
72	7.86	5.9	---	---	<0.5
96	8.01	6.8	---	---	<0.5
Solid phase					
0	7.62	7.7	---	19.3	4.5
24	8.31	9.2	10.9	11.8	2.5
48	8.41	9.7	6.6	4.6	<0.5
72	8.40	9.3	3.4	2.8	<0.5
96	8.40	9.1	3.4	---	---

(more)

Table 1. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	7.97	9.1	---	810	412
24	7.64	8.5	725	850	491
48	8.42	9.1	800	1,100	625
72	8.45	9.5	814	1,050	661
96	8.41	9.6	960	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 2. Characteristics of test media prepared from dredge spoil sediments from Truedale Slough in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Aerated control					
0	8.43	10.1	---	0.7	<0.5
24	8.43	9.6	0.9	1.5	<0.5
48	7.84	8.9	0.9	0.8	<0.5
72	8.42	9.3	1.3	1.1	<0.5
96	8.43	9.1	0.9	---	<0.5
Unaerated control					
0	8.38	8.8	---	---	<0.5
24	7.93	7.5	---	---	<0.5
48	7.81	5.9	---	---	<0.5
72	8.12	4.2	---	---	<0.5
96	7.94	5.0	---	---	<0.5
Solid phase					
0	8.48	9.5	---	2.7	29.5
24	8.42	9.5	4.8	5.1	4.0
48	7.89	7.8	4.1	2.4	5.5
72	8.37	8.2	2.4	2.8	10.0
96	8.31	7.5	2.9	---	---

(more)

Table 2. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	8.42	10.5	---	623	567
24	8.46	9.6	729	710	608
48	7.75	8.8	690	710	658
72	8.37	9.2	660	700	774
96	8.48	9.1	650	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 3. Characteristics of test media prepared from dredge spoil sediments from West Newton in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Aerated control					
0	8.11	8.8	---	0.7	<0.5
24	8.34	8.9	0.9	0.9	<0.5
48	8.30	8.9	1.2	1.0	<0.5
72	8.46	9.2	1.0	0.8	<0.5
96	8.41	9.5	1.2	---	<0.5
Unaerated control					
0	8.26	8.7	---	---	<0.5
24	7.91	6.5	---	---	<0.5
48	7.91	5.2	---	---	<0.5
72	7.99	5.5	---	---	<0.5
96	7.80	---	---	---	<0.5
Solid phase					
0	8.09	8.0	---	3.1	<0.5
24	8.30	8.7	3.0	2.2	<0.5
48	8.30	8.8	1.2	1.1	<0.5
72	8.39	9.0	0.9	0.8	1.0
96	8.39	9.3	0.7	---	---

(more)

Table 3. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	8.11	8.8	---	174	235
24	8.34	9.0	166	163	211
48	8.26	8.9	144	154	210
72	8.44	9.2	134	128	260
96	8.37	9.4	135	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 4. Characteristics of test media prepared from dredge spoil sediments from Somerfield Island in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Aerated control					
0	8.05	8.9	---	0.8	<0.5
24	8.38	9.1	0.8	1.8	<0.5
48	8.36	9.3	1.4	1.0	<0.5
72	8.42	9.3	1.7	1.5	<0.5
96	8.41	9.6	1.2	---	<0.5
Unaerated control					
0	8.29	8.8	---	---	<0.5
24	7.83	6.1	---	---	<0.5
48	7.88	5.0	---	---	<0.5
72	7.84	4.7	---	---	<0.5
96	7.83	6.1	---	---	<0.5
Solid phase					
0	8.03	8.1	---	17.0	1.0
24	8.24	8.7	22.0	17.0	16.0
48	8.31	8.8	13.0	9.7	16.0
72	8.36	8.9	6.7	6.6	8.0
96	8.36	9.4	6.9	---	---

(more)

Table 4. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	8.05	8.8	---	726	683
24	8.36	9.0	641	626	681
48	8.31	9.2	656	620	635
72	8.39	9.3	490	550	638
96	8.39	9.6	542	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 5. Characteristics of test media prepared from dredge spoil sediments from Island 58 in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Aerated control					
0	8.19	9.2	---	0.2	<0.5
24	7.90	9.6	1.3	1.3	<0.5
48	7.69	9.1	1.1	1.1	<0.5
72	8.23	9.5	2.1	1.2	<0.5
96	8.18	9.5	1.1	---	<0.5
Unaerated control					
0	8.19	8.9	---	---	<0.5
24	7.76	6.5	---	---	<0.5
48	7.71	4.9	---	---	<0.5
72	7.77	4.8	---	---	<0.5
96	7.85	4.2	---	---	<0.5
Solid phase					
0	8.19	8.9	---	5.5	6.3
24	7.93	9.3	8.4	7.0	5.0
48	7.81	9.0	3.9	3.1	<0.5
72	8.19	9.3	2.9	2.4	1.3
96	8.27	9.2	1.9	---	---

(more)

Table 5. (contd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a]		Suspended solids (mg/l)
			Before	After	
Particulate phase					
0	8.20	9.5	---	458	293
24	8.08	9.6	391	403	263
48	7.77	9.2	340	404	289
72	8.19	9.4	324	351	280
96	8.25	9.5	271	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 6. Characteristics of test media prepared from dredge spoil sediments from Grey Cloud Slough in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Aerated control					
0	8.45	9.2	---	0.4	<0.5
24	8.03	8.9	1.0	1.3	<0.5
48	8.26	9.1	1.0	0.8	<0.5
72	8.38	9.2	1.3	1.3	<0.5
96	8.40	9.1	0.8	---	<0.5
Unaerated control					
0	8.33	8.6	---	---	<0.5
24	8.17	6.4	---	---	<0.5
48	7.87	5.4	---	---	<0.5
72	8.12	4.3	---	---	<0.5
96	8.12	5.1	---	---	<0.5
Solid phase					
0	8.42	8.9	---	5.8	3.5
24	8.38	8.6	72.5	56.5	48.0
48	8.26	9.0	26.0	23.0	44.5
72	8.32	9.0	21.0	19.0	35.0
96	8.40	9.1	28.0	---	---

(more)

Table 6. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a]		Suspended solids (mg/l)
			Before	After	
Particulate phase					
0	8.33	8.9	---	3,090	5,188
24	8.08	8.7	2,600	2,860	4,423
48	8.23	9.0	3,020	3,470	5,905
72	8.32	9.2	2,670	3,200	5,865
96	8.37	9.1	2,420	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 7. Characteristics of test media prepared from dredge spoil sediments from below Cudahy in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Aerated control					
0	8.38	9.2	---	0.5	<0.5
24	8.33	9.4	1.9	2.5	<0.5
48	8.28	9.3	0.8	0.8	<0.5
72	8.31	9.2	1.6	1.3	<0.5
96	8.25	9.1	3.8	---	<0.5
Unaerated control					
0	8.40	8.6	---	---	<0.5
24	8.30	6.6	---	---	<0.5
48	8.08	6.3	---	---	<0.5
72	8.18	6.8	---	---	<0.5
96	8.03	6.3	---	---	<0.5
Solid phase					
0	8.38	8.6	---	11	9
24	8.28	8.9	75	47	30
48	8.24	9.1	26	30	58
72	8.28	9.2	14	15	86
96	8.29	8.9	50	---	---

(more)

Table 7. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	8.30	9.0	---	5,130	10,595
24	8.24	9.2	4,780	2,560	6,460
48	8.25	9.2	2,960	6,600	19,565
72	8.28	9.1	4,530	7,480	24,385
96	8.24	8.9	5,870	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 8. Characteristics of test media prepared from dredge spoil sediments from Winona Small Boat Harbor in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Aerated control					
0	7.95	8.9	---	0.2	<0.5
24	7.79	9.4	3.9	1.2	<0.5
48	7.71	9.1	1.4	1.3	<0.5
72	6.22	9.6	2.0	1.4	<0.5
96	8.11	9.2	1.4	---	<0.5
Unaerated control					
0	8.13	8.9	---	---	<0.5
24	7.81	8.2	---	---	<0.5
48	7.59	4.9	---	---	<0.5
72	7.81	4.6	---	---	<0.5
96	7.76	5.1	---	---	<0.5
Solid phase					
0	8.04	8.5	---	57	237
24	7.96	8.8	83	60	125
48	7.93	8.9	76	71	246
72	8.21	9.2	74	65	219
96	8.17	9.3	73	---	---

(more)

Table 8. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Particulate phase					
0	7.77	9.1	---	5,490	12,070
24	7.70	9.3	4,950	5,680	11,238
48	7.62	9.0	4,750	6,780	16,135
72	8.01	9.5	5,670	7,860	23,240
96	7.93	9.4	5,250	---	---

[a] NTU (Nephelometric Turbidity Units).

Table 9. Characteristics of test media prepared from dredge spoil sediments from Red Wing Commercial Harbor in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Aerated control					
0	8.43	9.5	---	1.1	<0.5
24	8.46	9.5	0.6	0.9	<0.5
48	8.10	8.8	0.7	2.2	<0.5
72	8.30	9.5	0.9	0.9	<0.5
96	8.43	9.0	0.7	---	<0.5
Unaerated control					
0	8.46	8.8	---	---	<0.5
24	8.24	6.8	---	---	<0.5
48	8.01	5.8	---	---	<0.5
72	7.99	4.1	---	---	<0.5
96	7.83	4.4	---	---	<0.5
Solid phase					
0	8.14	8.4	---	4.8	406
24	8.34	9.1	9.7	9.3	596
48	7.78	7.7	6.9	11.1	465
72	8.17	7.6	9.1	10.8	273
96	8.25	7.1	6.8	---	---

(more)

Table 9. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a]		Suspended solids (mg/l)
			Before	After	
Particulate phase					
0	7.89	8.4	---	20,640	58,775
24	8.07	9.2	13,260	22,520	57,380
48	7.81	8.4	22,560	23,560	63,345
72	8.02	9.3	20,800	27,680	82,815
96	7.99	8.5	20,120	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 10. Characteristics of test media prepared from dredge spoil sediments from St. Paul Barge Terminal in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	Turbidities[a] After	Suspended solids (mg/l)
Aerated control					
0	8.03	9.2	---	1.1	<0.5
24	7.86	7.7	---	1.4	<0.5
48	8.50	9.3	---	1.7	<0.5
72	8.59	9.3	---	1.7	<0.5
96	8.51	9.2	---	1.3	<0.5
Unaerated control					
0	7.75	8.4	---	---	<0.5
24	7.79	4.9	---	---	<0.5
48	7.86	5.3	---	---	<0.5
72	7.93	5.3	---	---	<0.5
96	8.11	4.9	---	---	<0.5
Solid phase					
0	7.73	7.3	---	65	240
24	8.45	9.0	358	434	206
48	8.38	9.0	511	318	193
72	8.35	9.2	398	385	262
96	8.34	---	105	---	---

(more)

Table 10. (cont'd)

Test situation and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
Particulate phase					
0	7.94	8.9	---	7,740	17,400
24	7.72	8.1	5,380	9,160	16,900
48	8.31	9.2	5,200	9,060	16,880
72	8.40	9.4	8,360	9,440	18,500
96	8.34	9.3	6,390	---	---

[a]NTU (Nephelometric Turbidity Units).

Appendix II

Summary of Chemical Characteristics of Delineative Test Solutions

Table 1. Characteristics of deliniative test media prepared from dredge spoil sediments from Truedale Slough in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
100%					
0	8.11	8.8	---	470	504
24	8.47	9.3	650	550	470
48	8.28	9.2	440	370	388
72	8.38	9.9	370	400	362
96	8.23	9.7	---	---	---
Average					431
90%					
0	8.09	8.9	---	420	464
24	8.46	9.3	550	400	412
48	8.32	9.4	405	310	328
72	8.41	10.0	340	350	316
96	8.23	9.8	---	---	---
Average					380
75%					
0	8.08	9.0	---	400	392
24	8.44	9.3	340	360	362
48	8.33	9.2	325	290	288
72	8.49	10.0	285	310	252
96	8.22	9.9	---	---	---
Average					324

(more)

Table 1. (cont'd)

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a]		Suspended solids (mg/l)
			Before	After	
50%					
0	8.09	8.9	---	360	246
24	8.42	9.4	260	230	214
48	8.32	9.2	260	195	190
72	8.49	9.9	205	230	156
96	8.23	9.9	---	---	---
Average					202
25%					
0	8.07	8.9	---	230	124
24	8.41	9.3	125	140	84
48	8.34	9.1	120	105	80
72	8.34	9.8	125	110	58
96	8.24	9.8	---	---	---
Average					87
Control 0%					
0	8.00	8.8	---	3.2	<0.5
24	8.36	9.3	6.3	4.3	<0.5
48	8.28	9.0	5.2	3.4	<0.5
72	8.43	9.9	4.5	3.8	<0.5
96	8.23	9.9	---	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 2. Characteristics of deliniative test media prepared from dredge spoil sediments from Red Wing Commercial Harbor in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
100%					
0	7.65	6.8	---	25,200	62,140
24	7.95	9.0	18,800	21,200	56,840
48	7.91	8.8	13,200	28,000	75,460
72	7.91	9.1	19,400	28,800	80,920
96	7.88	9.5	---	---	---
Average					68,840
90%					
0	7.68	7.4	---	19,600	52,980
24	7.99	9.0	15,800	19,000	53,800
48	7.91	8.6	14,800	19,000	54,620
72	7.95	9.8	17,400	18,800	57,660
96	7.89	9.5	---	---	---
Average					54,765
75%					
0	7.66	7.5	---	16,000	38,500
24	7.98	9.1	12,800	14,400	38,360
48	7.94	8.7	13,200	18,000	54,480
72	7.95	9.6	17,200	16,800	51,820
96	7.86	9.2	---	---	---
Average					45,790

(more)

Table 2. (cont'd)

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
50%					
0	7.77	8.6	---	11,000	24,440
24	8.07	9.1	9,300	9,500	19,080
48	8.03	8.9	8,000	11,800	26,860
72	8.02	9.8	11,000	10,200	26,040
96	7.88	9.5	---	---	---
Average					24,105
25%					
0	7.86	8.7	---	5,200	10,180
24	8.15	9.2	4,700	4,000	7,740
48	8.14	9.1	3,300	6,200	11,640
72	8.18	9.9	6,200	6,200	12,100
96	8.01	10.0	---	---	---
Average					10,415
Control 0%					
0	7.94	9.0	---	0.9	<0.5
24	8.17	9.1	2.4	1.5	<0.5
48	8.10	8.7	3.2	2.2	<0.5
72	8.35	8.8	5.2	3.6	<0.5
96	8.13	9.8	---	---	---

[a]NTU (Nephelometric Turbidity Units).

Table 3. Characteristics of deliniative test media prepared from dredge spoil sediments from St. Paul Barge Terminal in hard water at 17°C. Turbidities were taken before and 1 hour after batch replacement.

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
100%					
0	8.12	9.2	---	14,000	30,900
24	8.25	9.3	12,400	12,000	26,800
48	8.24	9.2	11,800	12,000	25,360
72	8.40	9.2	4,700	12,000	27,340
96	8.02	7.4	13,500	---	---
Average					27,600
90%					
0	8.23	9.4	---	10,000	17,760
24	8.26	9.2	9,400	9,000	16,320
48	8.22	9.4	8,600	9,200	18,400
72	8.39	9.2	8,700	10,000	21,260
96	8.00	8.2	10,400	---	---
Average					18,435
75%					
0	8.22	9.4	---	10,000	22,620
24	8.25	9.4	10,000	10,000	18,440
48	8.21	9.4	8,800	8,000	16,180
72	8.38	9.3	7,000	6,800	12,600
96	7.97	8.1	5,500	---	---
Average					17,460

(more)

Table 3. (cont'd)

Material composition and time (h)	pH	DO (mg/l)	Turbidities[a] Before	After	Suspended solids (mg/l)
50%					
0	8.22	9.5	---	8,300	18,100
24	8.25	9.4	7,100	7,800	16,560
48	8.22	9.4	7,600	6,700	12,120
72	8.37	9.2	4,500	5,500	10,260
96	7.98	8.3	4,200	---	---
Average					14,260
Control 0%					
0	8.28	9.2	---	2.4	<0.5
24	8.36	9.2	3.2	2.9	<0.5
48	8.29	9.3	3.2	1.6	<0.5
72	8.43	9.3	3.8	2.1	<0.5
96	7.98	9.0	2.9	---	---

[a]NTU (Nephelometric Turbidity Units).

DATE
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